

SEVERAL BIPLANES IN FLIGHT

CHAPTER XI.

PROMINENT TYPES OF BIPLANES

The number of biplanes built and under construction is so large that to give anything like a complete survey of the different makes is almost impossible.

There are, however, at present twenty distinct types, to one or the other of which almost all biplanes bear resemblance. Thus the Howard Wright, the Warchalowski, and the Aviatic, as well as many American biplanes, closely resemble the Farman. The German Albatross biplane is merely a counterpart of the Sommer, and in America there are twenty or more successful "imitations" of the Curtiss type, and a few that follow the Wright. The Caudron S. A. F. A., resembles the other French "tractor screw" biplanes in many respects, and the Euler closely follows the Voisin.

The twenty types of biplanes considered here are:

1. Breguet
2. Cody (1909)
3. Cody (1911)
4. Curtiss
5. Dufaux
6. Dunne
7. H. Farman (1909)
8. H. Farman (Michelin)
9. Maurice Farman
10. Goupy
11. Neale
12. Paulhan
13. Sommer
14. Voisin (1909)
15. Voisin (Tractor)
16. Voisin (Bordeaux)

17. Voisin (Front Control, 1911)
18. Wright (1909)
19. Wright (Model R)
20. Wright (Model B)

1. THE BREGUET BIPLANE

M. Louis Breguet has been experimenting for many years at Douai, France, and has gradually evolved, step by step, one of the most perfect flying machines yet constructed. It is interesting to note that the first successful helicopter to lift a man was built by him in conjunction with M. Richet in 1907, the total weight lifted being 1,100 pounds. The elegance of lines and the simplicity of his new biplane have resulted only from patient and diligent study of the subject. This machine is especially remarkable for its great excess of lifting force and the wonderful steadiness with which it "volplanes."

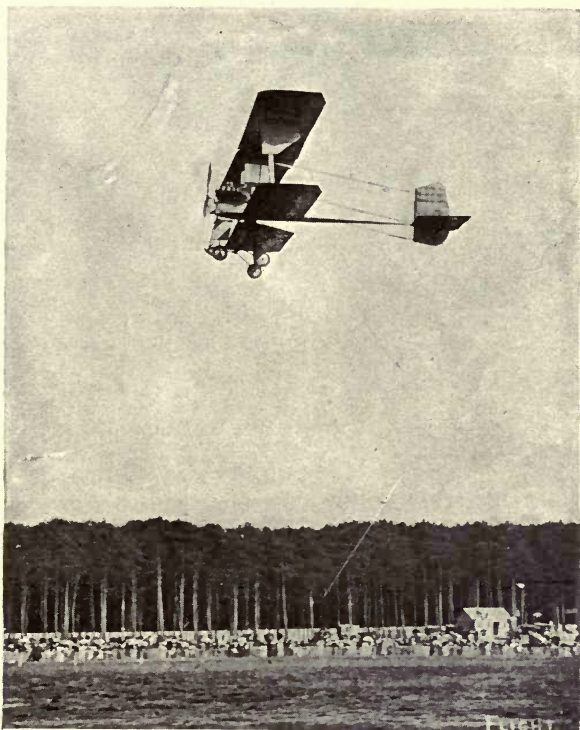
On April 8th, 1910, the Breguet biplane lifted three people at once and flew with such great ease, that the attention of the aviation world was attracted to Douai. At Rouen, at Rheims, and at many other foreign meetings, the Breguet biplanes, driven by M. Breguet himself and by Bathiat, not only won many prizes for passenger flights, but proved to be extremely speedy and reliable.

During the French Army Manœuvres, M. Breguet, with the late Capt. Madiot, made some excellent reconnoitering trips.

On September 1st, 1910, a flight was made with five persons aboard, the pilot and four passengers making a total load of 750 pounds. This performance was exceeded, by the same machine a few weeks later, when the pilot and five passengers made an excellent flight, the total load carried being about 860 pounds. This performance, however, has quite recently been exceeded by Sommer and Blériot. On December 31st, 1910, the Breguet made a distance flight of 205 miles.

The Frame.—The Breguet biplane is one of the few present-day types in which wooden framework is practically eliminated. A long covered fuselage, rectangular in section at the front and semicircular at the rear, gradually tapers to a point, giving practically a "stream line" form. This frame is made of steel tubing

at the front, but at the rear, where great strength is not so necessary, there are some wooden crosspieces. The motor is mounted at the front end; the planes are also at the front; the pilot sits back of the planes with a passenger seat in front of him, approxi-



Courtesy of "Flight."

BATHIAT FLYING ON THE BREGUET BIPLANE AT ROUEN,
JUNE, 1910

mately over the center of pressure; and at the rear are carried the rudders.

Supporting Planes.—The framework of the main planes consists essentially of two main steel tube cross pieces to which are fixed the numerous ribs. The ribs are made of a U-shaped piece of aluminum sheeting, and are fastened to the steel tubes by an

ingenious elastic joint. The entire frame is covered with a specially smoothed and oiled fabric.

The section of the planes is an evenly curved one, thick and blunt at the front and narrowing to a fine edge at the rear.

The planes are not of the same size, the lower one being smaller than the upper. They are, however, directly superimposed, and are mutually supported and fixed to the framework by only four vertical steel tube struts. The "box cell" arrangement is altogether absent. The planes are braced by steel rods to the central frame, and the usual maze of cross-wires is eliminated. This type of construction reduces the head resistance, and considerably increases the lifting force for a given horse-power.

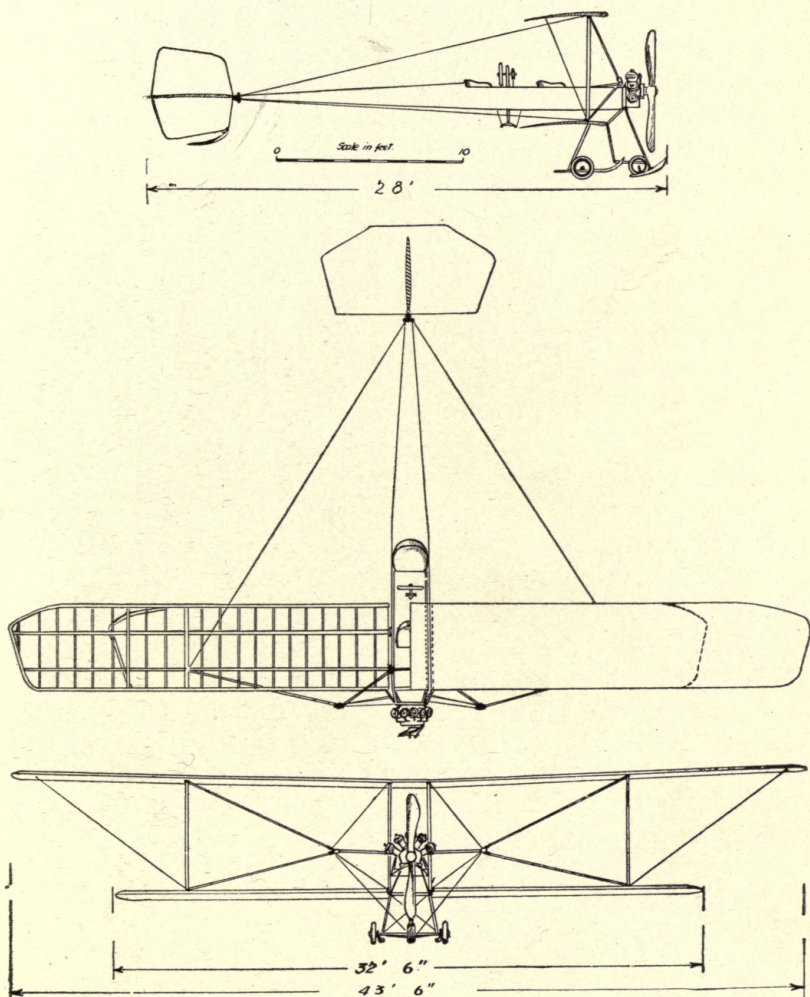
By reason of the great elasticity of the planes, they give a little under pulsations of the wind, and transmit the disturbing forces of the air waves to the frame, greatly diminished. The aeroplane is therefore suspended elastically in its element, and is in consequence assured of a higher degree of stability and a lesser fatigue of its parts.

It is possible because of this elasticity that, similar as it is to the elasticity of a bird's wing, the planes may profit by the "internal work of the wind," and thus is explained, in a measure, their high lifting quality.

The planes are about 7 feet apart. The upper ones are set at a slight dihedral angle. The spread of the upper plane is $43\frac{1}{2}$ feet, the spread of the lower plane $32\frac{1}{2}$ feet, and their depth $5\frac{1}{2}$ feet. The total supporting surface is 409 square feet.

Elevation Rudder.—At the rear of the machine, mounted on a universal joint and held by springs, is a cruciform tail-piece, the horizontal surface of which serves as the elevation rudder. This surface normally is "non-lifting," and has an area of approximately 25 square feet. By pushing forward on the steering column mounted in front of the pilot, the entire tail is turned down, thus lifting up the rear of the machine, reducing the angle of incidence of the main surfaces, and thereby causing the machine to descend. By pulling this column toward him, the aviator causes the machine to ascend.

Direction Rudder.—The vertical surface of the tail serves as the direction rudder, and is moved to either side by operation of the steering-wheel fixed on the control column.



SIDE ELEVATION, PLAN AND FRONT ELEVATION OF THE BREGUET BIPLANE "TYPE MILITAIRE"

Transverse Control.—The transverse equilibrium of the machine is controlled by the ordinary system of warping. By moving the entire control column, wheel and all, to the right, for example, the rear edge of the left plane is turned down, thus increasing the lift on that side.

Keels.—The cruciform tail-piece not only serves as a rudder for both elevation and direction, but in its normal position acts as a stabilizing *keel* of great power. Due to the springy character of this member, the stability is made somewhat automatic. If a sudden gust should hit the under side of the tail, the machine would tend to tilt up at the rear, and therefore descend. But this same gust would cause the tail to be turned up by an amount exactly proportional to the strength of the gust. Since a turning up of the tail is the movement for ascent, the tendency for the gust to cause the machine to descend will be counteracted in proportion to the strength of the gust. Since, in addition, the weight of this machine is great, and its momentum therefore quite large, this form of stabilizing device does actually act, and very forcibly hold, the machine to its course.

Propulsion.—The motor is placed at the front, and drives the propeller through reducing gear. A 40 to 50 horse-power motor is necessary, the usual types used being the Gnome, Renault or R. E. P. The propeller was formerly a three-bladed Breguet metallic one, but of late a two-bladed Chauviere wooden "Integral" has been used, almost 9 feet in diameter, $6\frac{1}{2}$ feet pitch, and rotating at 800 r.p.m.

Mounting.—The mounting is mainly on a set of two heavy rubber-tired wheels fitted on skids with oleo-pneumatic springs under the centre of gravity, and an extra heavy wheel and skid at the front to take very sudden landing shocks and protect the front of the frame, propeller, etc. This wheel can be turned as on an automobile.

Weight, Speed, Loading and Aspect Ratio.—

The total weight of the machine in flight varies from 1,100 pounds with pilot alone, up to 1,800 pounds with six aboard. The speed is approximately 53 miles an hour. The maximum pounds lifted per horse-power are 36, and maximum loading is 4.4 pounds

per square foot of carrying surface. The aspect ratio of the upper plane is 7.9 to 1—an extremely high value.

There is also a 60 horse-power "racing type" of Breguet biplane, for which a speed of 62 miles an hour is claimed. The characteristics of this machine are: Spread of upper plane, 40 feet; spread of lower plane, 30 feet; depth, $4\frac{1}{4}$ feet; surface area, 280 square feet; weight, 1,300 to 1,500 pounds; pounds per horsepower, 25; pounds per square foot, 5.4; and aspect ratio of 7.1 to 1.

References.—Encycl. d'Aviation, v. 2, No. 14, p. 98; Flight, July 16th, 1910, p. 553; December 10th, 1910; Aero, October 26th, 1910; November 2nd, 1910, p. 350; Flugsport, October 19th, 1910. V. Quittner and A. Vorreiter, "Neve Flugzeuge in Paris," Zeit. für Flugtech. und Motorluft., November 26th, 1910; Fachzeit. für Flugtechnik, November 13th, 1910, p. 15; L'Aerophile, February 1st, 1910, p. 58; June 15th, 1910, p. 273; July 15th, 1910, p. 317; December 15th, 1910, p. 558.

References on the Breguet-Richet Helicopters.—L'Aerophile, September, 1907, p. 258; April 15th, 1909, p. 175; La Nature, v. 70, p. 36, 1907.

2. THE CODY BIPLANE (1909)

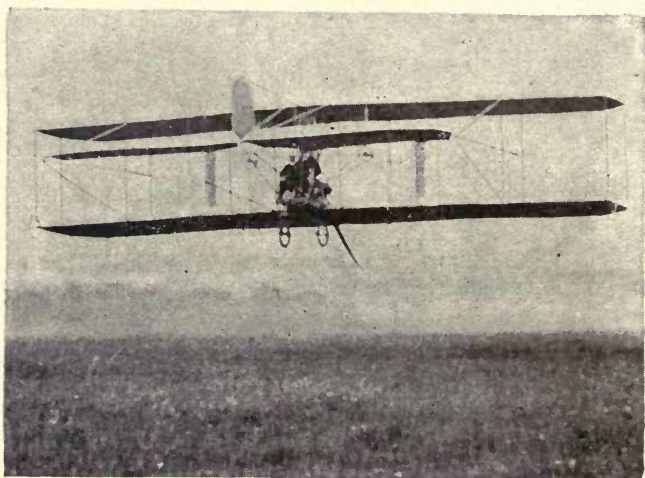
Col. Cody, an American, who has for some time resided in England, distinguished himself several years ago as the successful operator of man-lifting kites. His work in this line, with regard to army use and scouting, attracted much attention in England. In 1907, Col. Cody commenced work on a motor aeroplane of huge dimensions. At first the tests of this machine were very unsuccessful, but with remarkable perseverance Col. Cody gradually turned the failures into successes, and finally in the late summer of 1909 he accomplished a superb flight of over an hour, establishing then a cross-country record of the world. The machine was altered many times, and in its final form was the largest successful aeroplane ever flown.

The Frame.—Bamboo was used extensively throughout the frame, but all joints were carefully wound with steel wire. In addition there were many upright members of ash. At the center several members met in the supporting chassis which was very heavily built. Steel wire was used for bracing.

Supporting Planes.—The main planes were rectangular in

shape with rounded rear edges and were identical and directly superposed. The surfaces were made of canvas stretched tightly over wooden ribs. At the center the distance between them was 9 feet, but they converged toward either end, and were there separated by only 8 feet. The spread was 52 feet, the depth 7.5 feet, and the area 780 square feet.

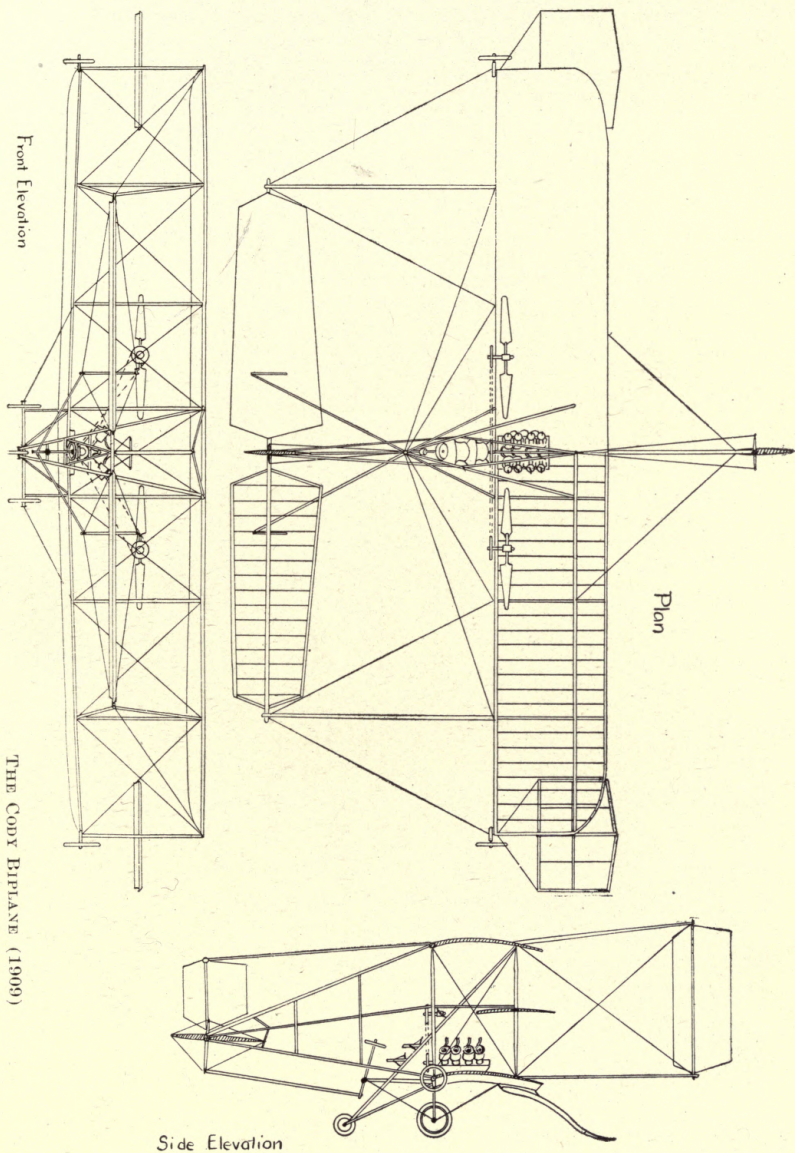
The Elevation Rudder.—At the front of the machine, supported by large bamboo outriggers from the central cell, were two



THE 1909 CODY BIPLANE IN FLIGHT

equal surfaces on either side of the center. These were jointly movable, and served to control the elevation of the machine. They were governed by the forward or back motion of the stanchion upon which the steering wheel was mounted. If the aviator wished to rise he pulled the wheel towards him. This motion, by means of a lever system, caused the elevation rudder surfaces to be lifted up to the line of flight and the machine ascended.

The Direction Rudder.—For steering to one side or the other two surfaces were used. At the rear of the machine was a large



vertical surface, which was the main direction rudder, while at the front was a smaller vertical surface used for the same purpose. These rudders were moved jointly by a cable and steering wheel, as in automobiles or motor boats. Their area was about 40 square feet.

Transverse Control.—Two balancing planes of 30 square feet area, one placed at either end of the main cell, controlled the transverse inclination of the machine. They were moved inversely by cables leading from the steering gear at command of the aviator. If the right end of the machine were depressed, then the wing tip on that side was turned down, but at the same time the wing tip on the other end was turned up. This caused not only the depressed side to rise, but also the raised side to be depressed, thus righting the machine. When making turns the machine could be artificially inclined with this apparatus. In addition to the wing tips, the transverse equilibrium could be controlled by the inverse movement of the two halves of the elevation rudder, the one on the depressed side being elevated while the other was turned down.

Keels.—There were no keels in this machine, all surfaces serving either to lift or to direct the aeroplane.

Propulsion.—The motive power was an 80-horse-power E.N.V. 8-cylinder motor. Two two-bladed propellers placed at the front of the main cell were driven in opposite directions by chains at 600 r.p.m. Their diameter was 8.25 feet, and their pitch 6 feet.

The Seats for aviator and one passenger were placed low at the center in front of the main cell. The lower seat was for the aviator, while the other was designed for the use of an observer in war time to take sketches of the enemy's position, etc.

The Mounting consisted of a large pair of wheels, which carried most of the weight, a small wheel in front of them, and a skid in the rear. Wheels were also fixed on each end of the lower plane to carry the machine easily over the ground if it should alight on one end.

Weight, Speed, Loading and Aspect Ratio.—

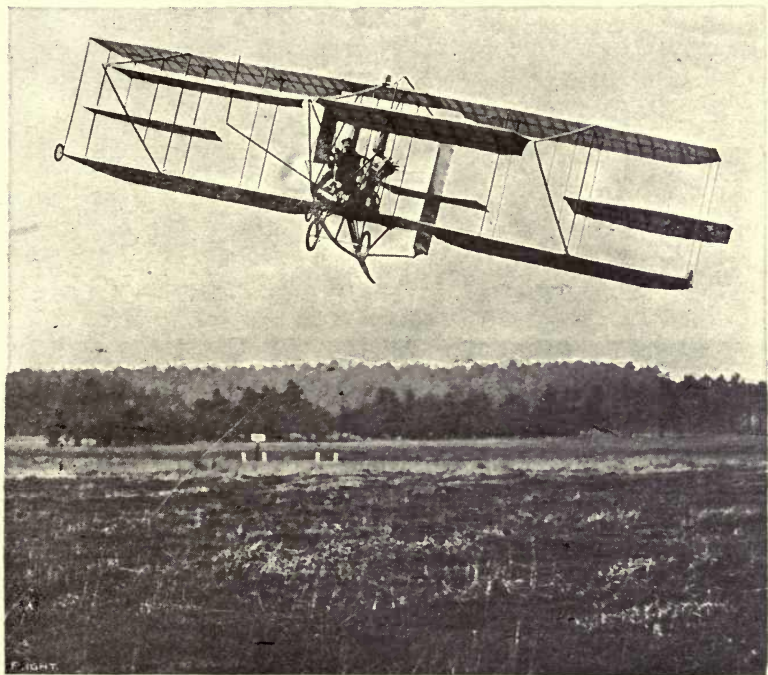
The total weight was from 1,900 to 2,100 pounds; the speed, 37 miles per hour; 25 pounds were lifted per horse-power, and 2.57

pounds per square foot of surface. The aspect ratio was 7 to 1.

References.—Zeit. Ver. Deut. Ing., v. 53, p. 1143; Aeronautics, v. 4, pp. 78, 126; v. 5, pp. 33, 65, 154; Flight, v. 1, pp. 113, 501; Encycl. d'Av., v. 1, p. 112; Boll. Soc. Aer. Ital., v. 6, p. 288; Vorreiter A., "Motor Flugapparate"; Sci. Am., v. 101, p. 198.

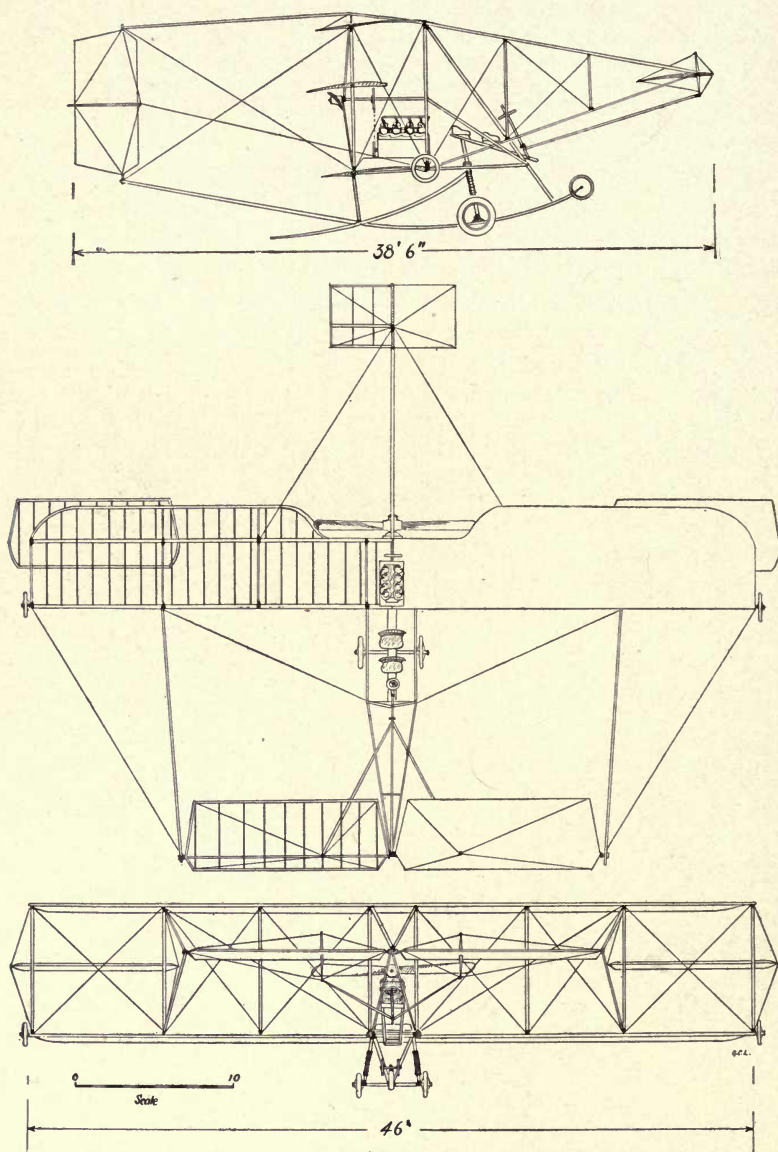
3. THE CODY BIPLANE (1911)

Col. Cody's newest biplane, in which he won the British Michelin prize by flying 186 miles at Farnborough on December 31st, 1910, greatly resembles its predecessor, but is smaller, and distinguished by its equipment with one propeller at the rear instead of two as formerly. The control system and rudders are precisely



Courtesy of "Flight."

MR. S. F. CODY ON HIS 1911 TYPE BIPLANE, COMPETING FOR THE BRITISH MICHELIN CUP, WHICH HE WON BY A FLIGHT OF 186 MILES.

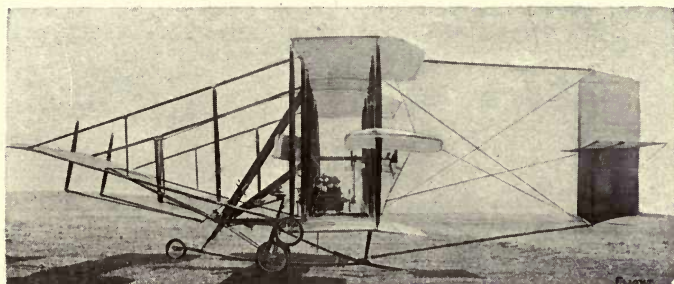


SIDE ELEVATION, PLAN AND FRONT ELEVATION OF THE CODY (1911)

the same the balancing forces being distributed over different parts of the machine, thus guarding against any undue local stress. The balancers are held normal by springs.

The Frame.—The frame and skid construction is very much simpler and stronger than formerly. Silver spruce is used in the frame, bamboo for the outriggers, and hickory for the chassis.

The Supporting Planes.—The two planes of the main cell, $8\frac{1}{2}$ feet apart, have a spread of 46 feet, a chord of $6\frac{1}{2}$ feet, and an area of 540 square feet. The depth of curvature is 4 inches,



Courtesy of "Flight."

SIDE VIEW OF THE CODY (1911)

and the shape of the section has a curious narrowing between the spars. The surface is double and made of Pegamoid cloth.

The Elevation Rudder.—The elevating surfaces at the front have a total area of 116 square feet, a depth of $4\frac{1}{2}$ feet, and are 12 feet in front of the main cell. The control is the same as on the 1909 type.

The Direction Rudder.—The front direction rudder is eliminated. The one at the rear is retained, and has an area of 36 square feet.

Transverse Control.—Transverse control is, as on the former type, by means of ailerons and the two halves of the front rudder. The ailerons are each 50 square feet in area.

Keel.—A new departure is the addition of a horizontal non-lifting keel at the rear.

Propulsion.—A 60 horse-power E. N. V. or Green motor, placed on the lower plane, drives by chain a single large wooden-bladed propeller, $10\frac{1}{2}$ feet in diameter and 10.6 feet pitch, at 600 r.p.m. This is the largest propeller used on any aeroplane up to the present.

A new and smaller type with a 35 horse-power engine is being built.

Speed, Weight, Loading and Aspect Ratio.—

The speed of this machine is about 41 miles an hour. The total weight is 1,350 to 1,500 pounds; 25 pounds are lifted per horse-power, and 2.8 per square foot of surface. The aspect ratio is 7.1 to 1.

References.—Flight, 1910, November 12th, p. 923; November 19th, p. 945; Aero, 1910, October 5th, p. 276; October 12th, p. 288, Fachzeit. für Flugtechnik, No. 42, p. 19.

4. THE CURTISS BIPLANE

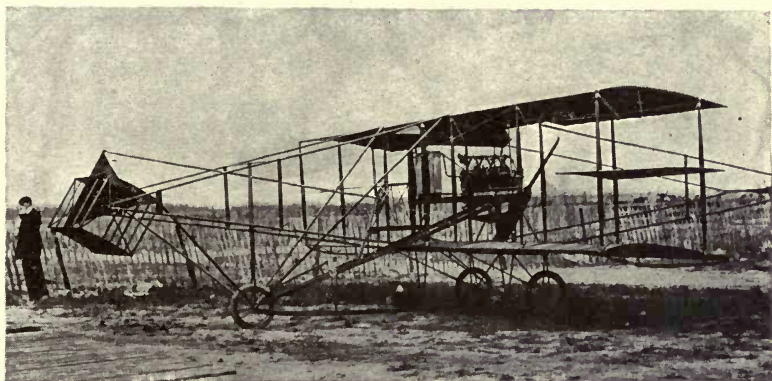
The Curtiss biplane, originated by the Herring-Curtiss Company, embodies in its construction several features that distinguished the aeroplanes built by the Aerial Experiment Association, of which Mr. Curtiss was a member. In June, 1909, the first flight of this type was made. At Rheims, in August, this miniature biplane, ably piloted by Mr. Curtiss, captured the Gordon Bennett Prize and Cup as well as several others. It is one of the fastest biplanes now in use. Several machines of this type are being flown, notably by Messrs. Curtiss, Mars, Hamilton, Willard, McCurdy, Ely, Post, and Baldwin. There is no other type that has been as widely imitated by amateurs in this country as the Curtiss.

The Frame.—The main cell and smaller parts are made of ash and spruce, and the large outriggers, of bamboo. Several members of the frame meet at the front wheel. Small cables as well as wires are used for bracing.

The Supporting Planes.—The main carrying planes are of very finished construction. They consist of two identical directly superposed surfaces made of one or two layers of Baldwin rubber silk,

tacked to spruce ribs and laced to the frame. A distance of 5 feet separates the surfaces. Their spread is 26.42 feet, the depth 4.5 feet, and the area 220 square feet.

The Elevation Rudder.—The elevation rudder is a small biplane cell consisting of two identical surfaces, 24 square feet in area, mounted at the front on bamboo outriggers. It is governed by a long bamboo rod attached to the stanchion on which the steering wheel is mounted. By pushing out on this, the rudder is turned down and the machine descends. By pulling in, the machine is caused to ascend.

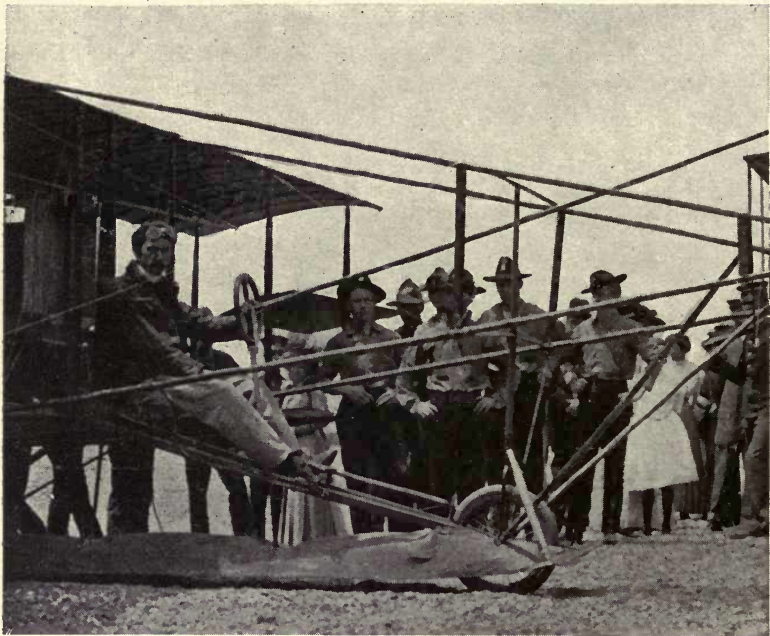


THE CURTISS BIPLANE, WHICH WON THE INTERNATIONAL CUP AT RHEIMS IN AUGUST, 1909

The Direction Rudder.—The rudder for steering from right to left consists of a single vertical surface placed in the rear and operated by the steering wheel and cables, which are run inside the bamboo outrigger. Its area is 6.6 square feet.

Transverse Control.—Two balancing planes of 12 square feet area each, one placed at either end of the main cell, are used to preserve lateral balance. They are tipped inversely by means of a brace fitted to and swayed by the aviator's body. If the machine is depressed on the left side, the aviator leans toward the right, and in so doing moves the brace, causing the wing tip on the

left side to be turned down and the one on the right to be turned up, thus righting the machine. By "turning down" is here meant a motion relative to the axis of the wing tip itself and not to the line of flight. When a wing tip of this sort is turned down, its incidence, i. e., the angle it makes with the line of flight, is positive and it therefore exerts a greater lifting force.



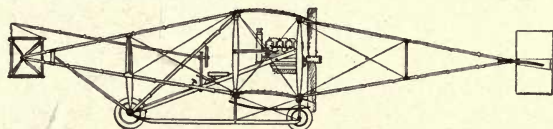
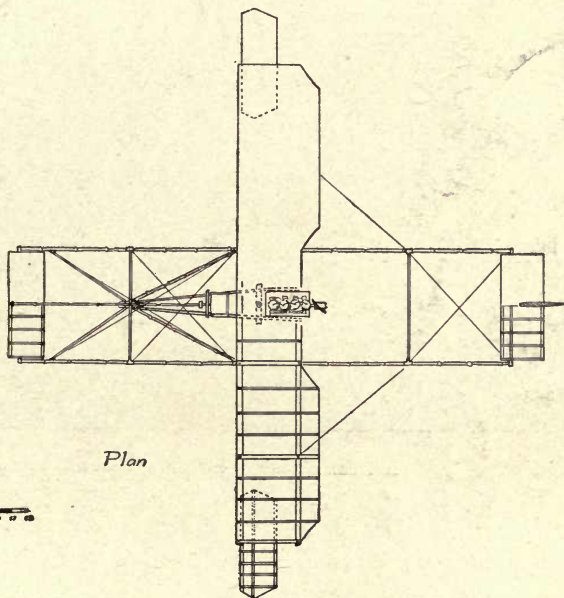
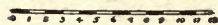
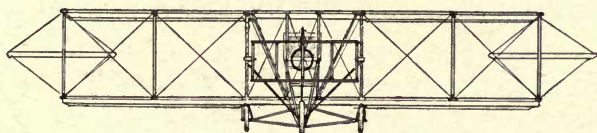
GLEN CURTISS AFTER HIS ALBANY-NEW YORK FLIGHT

When making a turn to the right, for example, the aviator, by leaning to the right, and thus causing the left end to lift up, can make a sharper turn than by use of the direction rudder alone.

Keels.—A horizontal fixed surface is placed in the rear and steadies the machine greatly. Its area is 15 square feet. A small triangular vertical surface is sometimes placed in front.

Propulsion.—A 25 horse-power, 4-cylinder Curtiss motor,

placed well up between the two surfaces at the rear, drives direct a two-bladed wooden propeller at 1,200 r.p.m. The propeller has a pitch of 5 feet and a diameter of 6 feet.

*Side Elevation**Plan**Scale of feet**Front Elevation.*

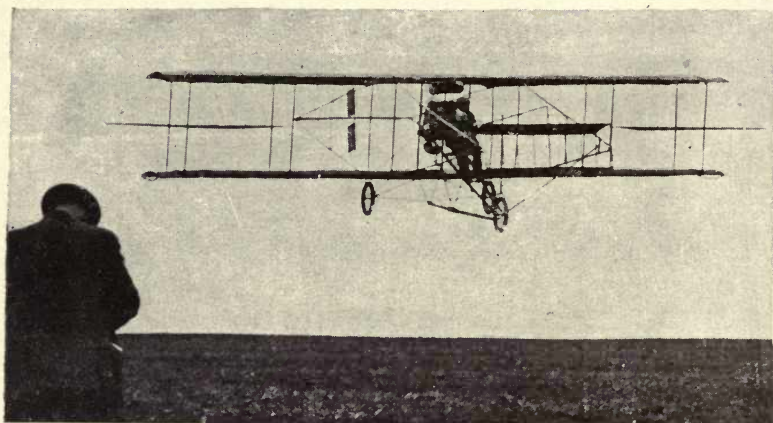
PLAN AND ELEVATIONS OF THE CURTISS BIPLANE

The Seat for the aviator is on the framing in front of the main cell and in line with the motor. When a passenger is carried a seat is provided to the side and somewhat below the aviator.

The Mounting is on three rubber-tired wheels, rigidly fixed to the frame, no springs being provided.

Weight, Speed, Loading and Aspect Ratio.—

The total weight is from 530 to 570 pounds, and the speed is 47 m.p.h.; 22 pounds are lifted per horse-power and 2.5 pounds per square foot of surface. The aspect ratio is 5.65 to 1.



A NEAR FRONT VIEW OF A CURTISS BIPLANE

Recent Alterations.—Mr. Willard has recently flown a larger type of Curtiss biplane, in which he has succeeded in carrying three passengers besides himself.

This machine is precisely of the same general design as the regular Curtiss type, but differs from it in size.

The supporting planes have a spread of 32 feet, a depth of 5 feet, and an area of 316 square feet. The elevation rudder is 31 square feet in area, and the direction rudder 7.5 square feet in area. The rear horizontal keel has an area of 17.5 square feet, while the ailerons are each 27 square feet in size. A Curtiss 8-

cylinder 50 horse-power motor is used and drives direct a 7-foot propeller at 1,100 r.p.m. The maximum total weight in flight is 1,150 pounds. 22.6 pounds are carried per horse-power, and 3.64 pounds per square foot of surface. The aspect ratio is 6.4 to 1.

In most of the latest Curtiss machines, a single plane elevation rudder is used, and the side ailerons are replaced by four flaps on the trailing edges of the planes, or are placed on either side at the rear of the cell.

In the new machine used by Mr. Curtiss in his recent interesting experiments over water, the single plane elevation rudder is aided in its action by movable flaps on the rear of the horizontal keel at the back, a disposition similar to that used on the Farman biplanes. The fan shape of this rear keel as on Mr. Ely's machine is also a new departure.

References.—Aeronautics, v. 5, p. 13, 86, 137; Am. Aeronaut, v. 1, p. 1 (new series); Boll. Soc. Aer. Ital., v. 6, p. 286; SCI. AMERICAN, v. 100, p. 460; Encycl. d'Av., v. 1, p. 24; Am. Machinist, v. 32, p. 49; Flight, v. 1, p. 389; Zeit. für Luft., v. 13, p. 816; Aerophile, v. 17, p. 488; Locomocion Aerea, v. 1, p. 78; Genie Civil, v. 55, p. 343.

5. THE DUFAUX BIPLANE

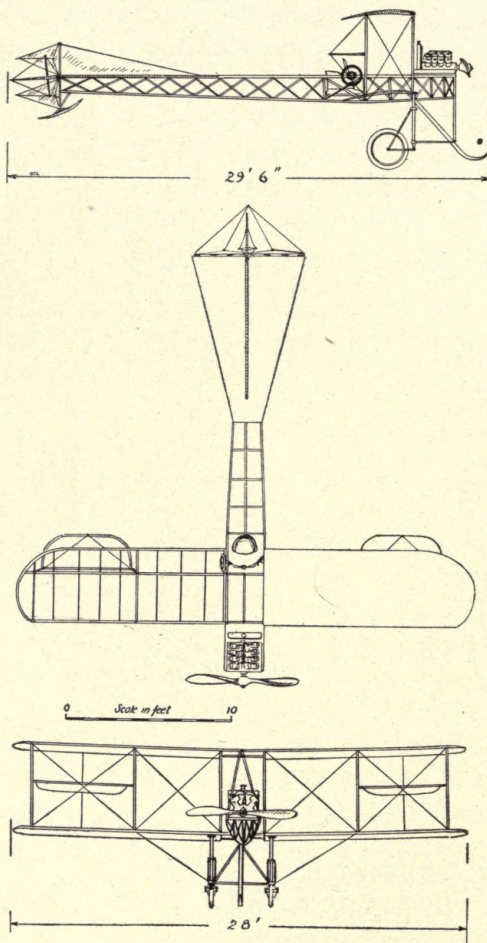
This biplane, built in Switzerland by the Dufaux Brothers, is one of the most successful types of biplanes equipped with a tractor screw. It is noteworthy for its light weight. Excepting the main surfaces, the Dufaux resembles the Antoinette more than any other type, and possesses some of the gracefulness that is so characteristic of that monoplane. Many excellent flights have been made by this machine, among them a 36-kilometer flight on July 12th, 1910. Toward the end of August, the Dufaux biplane was flown across the Lake of Geneva, a distance of 41 miles, with perfect ease and at high speed.

As early as October, 1905, the Dufaux Brothers were experimenting with heavier-than-air machines. At this date they had built a very light engine and applied it to a helicopter. This apparatus succeeded in lifting 54 pounds.

In the summer of 1908, an interesting triplane was built by

them, 650 square feet in area and equipped with a 125 horse-power eight-cylinder motor. The total weight was 1,400 pounds.

The Frame.—The long central frame or *fuselage* of the Dufaix is similar to that of a monoplane, and the latticed framework itself reminds one strongly of the Antoinette. The disposition of



THE DUFAX BIPLANE, SIDE ELEVATION, PLAN AND FRONT ELEVATION

parts is exactly as on the ordinary monoplane, the motor and propeller being at the front, the rudders and keels at the rear, and the seat just back of the main planes.

The Supporting Planes.—The main planes are similar and directly superposed. They are constructed of the usual wooden framework covered above and below with rubber fabric. The two halves of the main cell are set at a slight dihedral angle. Their curvature is quite flat and narrow. The spread is 28 feet, the depth 5 feet, and the area 260 square feet.

Elevation Rudder.—The elevation rudder consists of a single horizontal surface at the rear, triangular in shape, and operated by a wheel at the aviator's right hand, exactly as on the Antoinette.

Direction Rudder.—The direction rudder consists of two triangular surfaces at the rear, similar to those on the Antoinette, but smaller. The direction is controlled by a foot pedal, which is turned to the right or left, according as the desired turn is to right or left.

Transverse Control.—The transverse control is effected by the use of ailerons, one pivoted at the rear of the main cell on either side and midway between the planes. The ailerons are operated by a lever in the aviator's left hand. By pulling the lever to the right, for example, the left aileron is turned down, thus increasing the lift on the left side.

Keels.—A vertical keel and a horizontal keel or *empennage*, both of which terminate in their respective rudders, are provided and greatly resemble the Antoinette.

Propulsion.—An eight-cylinder E. N. V. 50 horse-power motor is mounted at the front. The propeller is driven direct at 1,300 r.p.m., and is 7 feet in diameter. A radiator is placed back of the motor.

Mounting.—The mounting is essentially on two wheels fitted with springs on a steel tube chassis (*à la* Blériot) with a single skid projecting out in front at the center, similar to the Antoinette. There is also a small skid at the rear.

Weight, Speed, Loading and Aspect Ratio.—

The total weight in flight is about 550 pounds; 11 pounds are lifted per horse-power; and 2.1 pounds are carried per square foot of surface. The aspect ratio is 5.6 to 1.

References.—*L'Aerophile*, January 15th, 1910, p. 31;
October 1st, 1910; *Flight*, August 27th, 1910, p. 696.

6. THE DUNNE BIPLANE

The Dunne biplane, constructed in England by Short Brothers to the design of Lieut. J. W. Dunne, is very solidly built and presents a very unusual appearance. In the numerous flights that have been made at East-church, Isle of Sheppey, exceptional stability was exhibited by this biplane, and since its outstanding features are the absence of the usual elevation and direction rudders, and the curious shape of the main cell, it has excited much interest and comment.

It is said that the British army experimented with a prototype of this machine, in secret, some years ago.

The Frame.—The construction of the main cell is of the usual wooden and wire frame, canvas-covered type. At the centre there is built in a skiff-like body 18 feet long containing the motor, seat, controlling levers, radiator, etc.

The Supporting Planes.—The conspicuous feature of this machine is the employment of the dihedral principle, laterally, transversely, and longitudinally.

The general aspect of the main planes are evident from the accompanying scale diagrams.

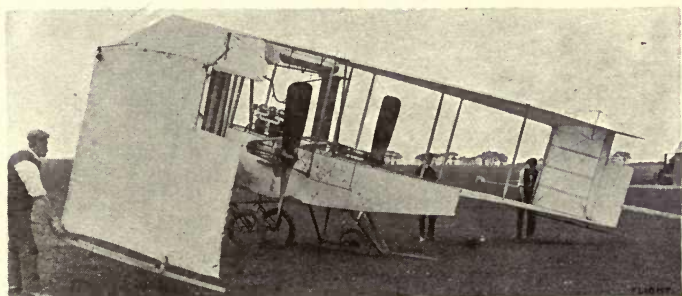
The greatest fore and aft direction is constituted by the wings themselves.

The incidence of the tips is much less than the incidence at the center. In flight the angle is very low indeed, and is certainly negative at the ends. The camber of the ribs is a very interesting feature. At the center the ribs have their greatest depth of camber far to the front, with a long straight portion to the rear. But at the ends the ribs are curved so that the greatest depth of camber is about at the center. The theory involved in this type of construction is very interesting, and indicates that by

making use of the variations in position of the center of pressure a semi-automatic balance is obtained.

The planes are 6 feet apart, 6 feet in depth, and spread 20 feet $4\frac{1}{2}$ inches longitudinally and 46 feet laterally. The total area is 527 square feet.

Elevation.—At the rear ends of each plane are hinged flaps, each $7\frac{1}{2}$ feet wide and $12\frac{1}{2}$ square feet in area, controlled by a left-hand and a right-hand lever. They are so connected that when the right-hand lever is pulled back, and the left-hand lever is



Courtesy of "Flight."

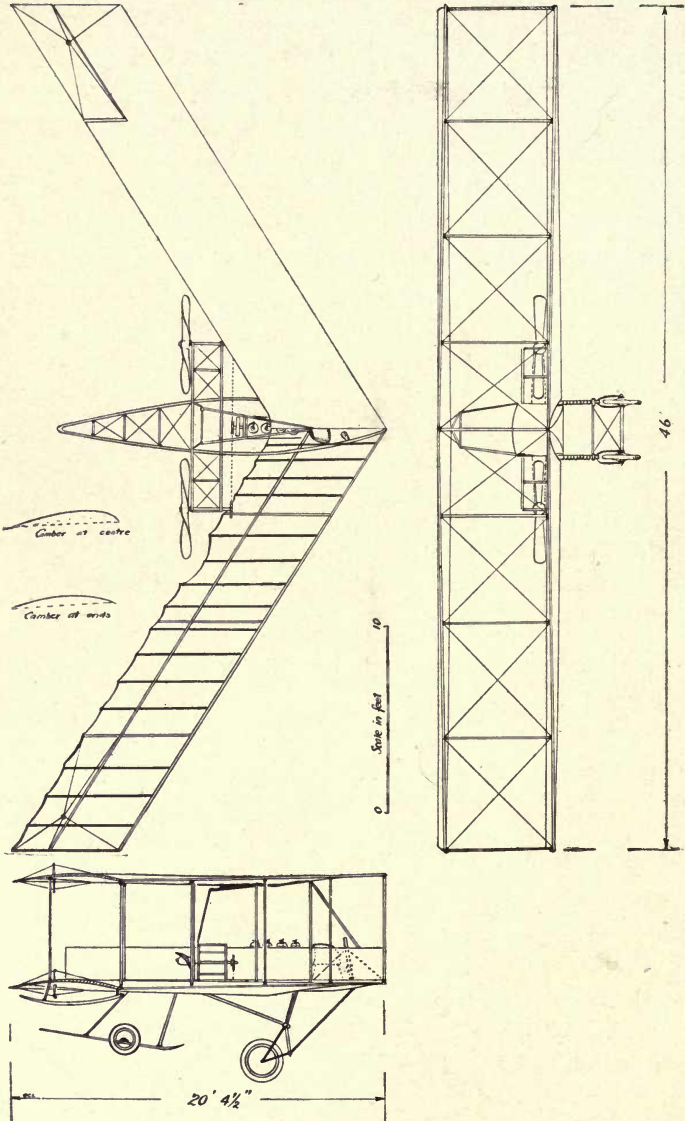
A REAR THREE-QUARTER VIEW OF THE DUNNE BIPLANE

This photograph is worthy of study because it gives the correct impression of the shape, and slope of the main planes.

pushed forward, then the left ailerons are pulled down, lifting up that side and the right ones are turned up. When both levers are pulled back together, both flaps are turned up, and since they are to the rear of the center of support, the entire machine will be turned up for ascent.

Direction.—When steering to the right, for example, the right lever is drawn back and the left pushed forward, thus pulling up the right flap and pulling down the left.

The angle of incidence of the ends is always negative. Therefore turning up the right flap increases still further the negative incident angle, and consequently greatly increases the negative drift, thus causing the right side of the machine to slow down, at the same time as it is depressed. But since the flaps are at the



THE DUNNE BIPLANE. PLAN AND ELEVATIONS

rear of the center of gravity, and since turning up the right flaps causes this end to sink (like the tail of a Blériot, for example), there is a tendency for the entire machine to ascend. To counteract this, the left lever is pushed over, thus increasing the lift on this end and decreasing the negative incident angle. This now results in a decrease of drift on this side, and causes the machine to "skew" around faster and to "bank" with the right down and the left up.

Transverse Control.—The character of the planes on this biplane give it practically an automatic transverse equilibrium, so that there is no distinct and separate manner of controlling the lateral inclination of the machine. The manner in which this aeroplane is artificially inclined when making turns, however, has already been described.

Keels.—The end panels of the main cell are covered-in, giving a vertical keel at each side, which aids materially in the various movements for equilibrium and holds the machine to its course, preventing any skidding sideways, etc.

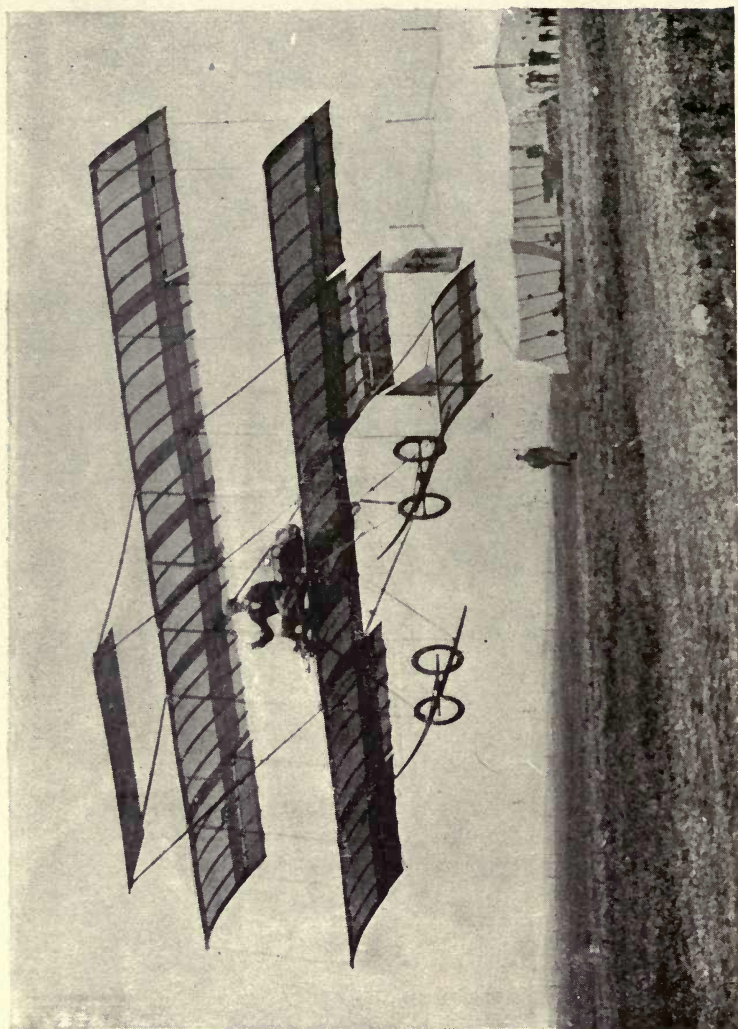
Propulsion.—Two wooden propellers are mounted on a frame built out on either side of the central body. These propellers are 7 feet in diameter, $7\frac{1}{2}$ feet pitch, and rotate at 660 r.p.m. They are driven by chains from a 50 horse-power four-cylinder Green engine, and are rotated in the same direction. To counteract the torque resulting from this, a weight is fixed on one end of the machine. This is not a very good provision.

Mounting.—The mounting is similar to the old Voisin type, and consists of two rubber-tired wheels mounted on a steel-tube chassis fitted with coiled steel springs at the front and a single wheel and skid at the rear.

Weight, Speed, Loading and Aspect Ratio.—

The total weight in flight is about 1,700 pounds, 34 pounds are lifted per horse-power, and 3.2 per square foot of surface. The aspect ratio, considering the actual width of the planes, is 9 to 1, and considering the projected span of 46 feet, is 7.6 to 1.

References.—Flight, June 4th, 1910; June 18th, 1910, p. 459; June 25th, 1910; Flugspport, July, 1910.



GRAHAME-WHITE ON HIS FARMAN BIPLANE AT BOSTON, SEPTEMBER, 1910

7. THE FARMAN BIPLANE (1909)

Henri Farman, in 1907, began his career as an aviator by making short flights of a few seconds duration on a biplane constructed for him by the Voisin brothers. On January 13th, 1908, he succeeded in flying one kilometer in a closed circuit, thereby winning the Deutsch-Archdeacon prize, the first great prize offered for an aeroplane flight. Until the end of that year Farman flew this machine and with it conducted a series of experiments on stability. In the early part of 1909, having severed his connection with the Voisins, Farman opened an aeroplane factory at Chalons, France, and began manufacturing aeroplanes himself. His design was original in many ways, and embodied several practical innovations that his previous experience had suggested.

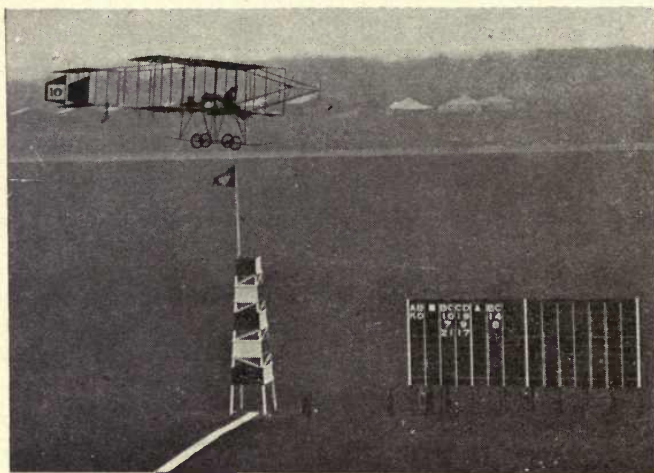
The Farman biplane has been used extensively in Europe, and notably by the well-known aviators Paulhan, Weyman, White, etc. More than one hundred of this type are in use or under construction, and for a slow but trustworthy machine it has been found very satisfactory.

The Frame.—The frame consists essentially of a main box cell, somewhat similar in design to a Pratt truss, counterbraced throughout, with identical upper and lower chords, uprights of wood acting as compression members and cross wires as tension members. The supporting planes are analogous to the upper and lower decks of such a truss.

The Supporting Planes.—There are two main carrying surfaces, identical and directly superposed. Their sectional curvature is of the cambered shape, used so generally in present day aeroplanes. The curvature is concave on the under side, and of parabolic character. The surfaces are made of "Continental" cloth, a special rubber fabric, stretched tightly over ash ribs. The spread of the surfaces is 33 feet; the depth, 6.6 feet, and the total area, 430 square feet. The distance between planes is 7 feet.

The Elevation Rudder.—The elevation rudder originally consisted of a single surface, about 43 square feet in area situated well out in front. It was hinged and braced to two sets of outriggers, firmly attached to the main cell, and was controlled by

a large lever in the aviator's right hand. By pulling in on this lever, the rudder was tilted up and the machine was caused to rise. By pushing out on the lever, the rudder was dipped down and the machine was caused to descend. This method of control is almost instinctive and very easy to acquire. On the more recent types this front rudder is reduced in size and in addition the rear flap of the upper keel at the stern is moved jointly with it.



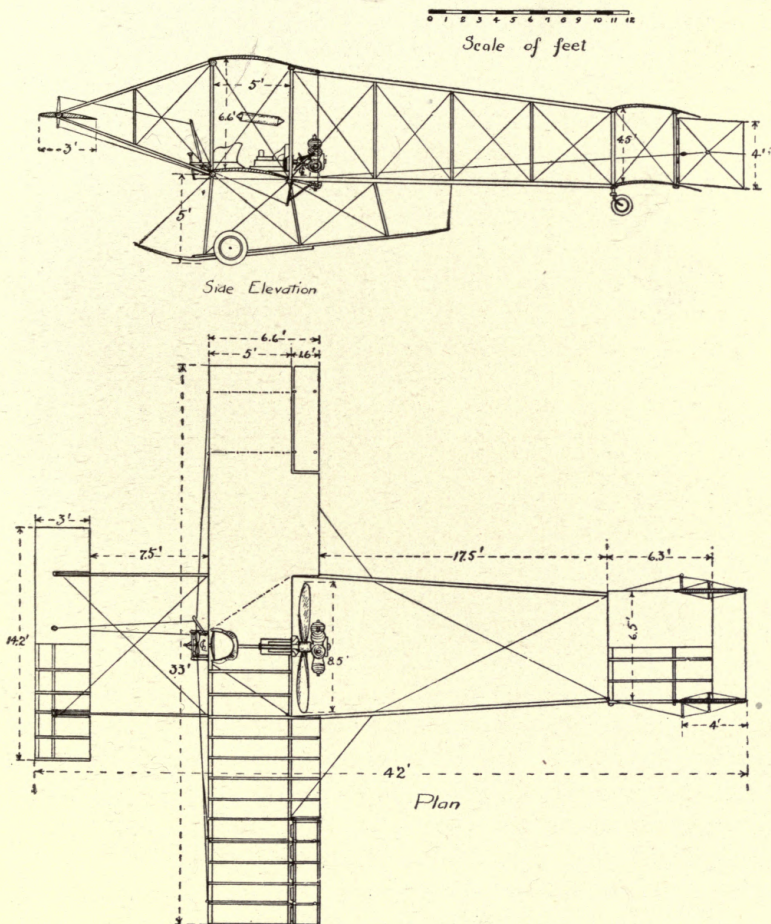
GRAHAME-WHITE ON HIS FARMAN AT BELMONT PARK

The rudders and ailerons are all in their normal positions. The bulletin board indicates that he has just completed 19 laps in an hourly distance event. Note the hangars and tents in the distance.

The Direction Rudder.—Two equal vertically placed surfaces in the extreme rear serve as the direction rudder. They are moved jointly and have an area of approximately 30 square feet. A foot lever, hinged at its center, is so connected to these rudders by cables that when the aviator pressing on this lever with his feet turns it, for example, to the left, then the machine will turn to the left.

Transverse Control.—The control of the lateral equilibrium i. e., the tipping from side to side, is effected by the use of "wing

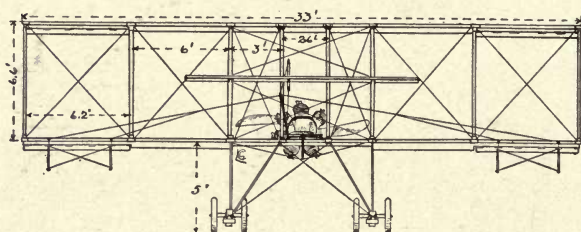
tips," four flaps constituting the rear ends of each plane. A lever in the aviator's right hand (the same one as used to operate the elevation rudder) can be moved from side to side. It is connected by wires to the lower flap on either side. These flaps in turn transmit the movement imparted to them by the lever to the flaps



SIDE ELEVATION AND PLAN OF THE FARMAN BIPLANE WITH WHICH HENRI FARMAN WON THE MICHELIN PRIZE IN 1909

directly above them by means of a further wire connection. When the machine is standing still the flaps merely hang down loosely and the wires relax. But as soon as the machine takes to flight the flaps fly out, very much like a flag blown by the breeze, and in this position the connecting wires are extended their full length, and the lever is in control.

If, for example, the machine should tip suddenly down on the aviator's right side then the lever is promptly moved over to the left. This action causes the flaps on the right end of the machine to be pulled down, and since this involves an increased angle



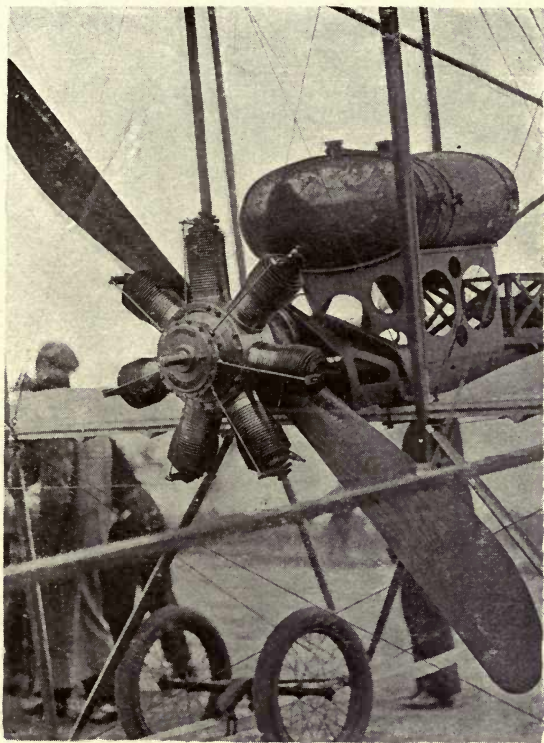
FRONT ELEVATION OF THE FARMAN BIPLANE

of incidence of the flaps, the lift they exert is increased. This is sufficient to bring the machine back to an even keel. During this process the wires leading to the flaps on the other end have been relaxed, since both sets of connecting wires are taut only when the lever is in mid-position. The flaps on the opposite end, therefore, have in no way been affected, except to be able to fly out more freely in the wind stream.

When making turns, in addition to using the direction rudder, the machine is often artificially inclined by the use of the transverse control. When turning to the right, for example, an instant before setting the direction rudder the lever is moved over to the right side. This lifts up the left end of the machine and therefore causes the turn to be sharper.

Keels.—Two horizontal surfaces at the rear, of approximately 80 square feet area, act as keels. Their angle of incidence is low,

and the lift they exert is small, their only function being to steady the machine longitudinally.



THE GNOME ENGINE PROPELLER AND FUEL TANK OF
PAULHAN'S FARMAN BIPLANE

Note the rubber band spring between the skid and axle
of wheels.

Propulsion.—A 50 horse-power 7-cylinder, Gnome rotary, air-cooled motor is mounted on a shaft in the rear of the lower plane. A two-bladed Chauviere wooden propeller is directly connected to this motor and rotates with it at 1,200 r.p.m. The pitch of the propeller is 4.62 feet and its diameter is 8.5 feet.



HENRI FARMAN WITH 2 PASSENGERS

Note the control levers and wires leading to the rudders and ailerons.

The Seats for aviator and two passengers are placed on the front of the lower plane.

The Mounting, or apparatus upon which the machine starts and alights, consists of two long skids forming part of the framework, upon each of which is mounted a pair of wheels. When starting, this machine runs along the ground on its wheels, but when alighting, the wheels, which are attached to rubber springs, give way, and the machine lands on its skids.

Weight, Speed, Loading and Aspect Ratio.—

The total weight varies greatly with the amount of gasoline taken aboard, the number of passengers, etc. The limits within which this value lies, however, are given and all calculations are made for an approximate mean weight of the machine with aviator aboard ready for flight. The weight of the Farman machine is from 1,100 pounds to 1,350 pounds; the speed, 37 miles per hour; 24 pounds are lifted per horse-power and 2.8 pounds per square foot of surface. The aspect ratio is 5 to 1.

Recent Alterations.—Some of the more recent types of Farman machines are fitted with a single surface direction rudder, instead of the twin surfaces. The elevation rudder, in front, is made smaller, and in addition the rear end of the upper of the two fixed horizontal keels (at the rear of the machine) is made movable conjointly with the front rudder to control the elevation of the machine as already noted. In some of the machines only one surface is used at the rear.

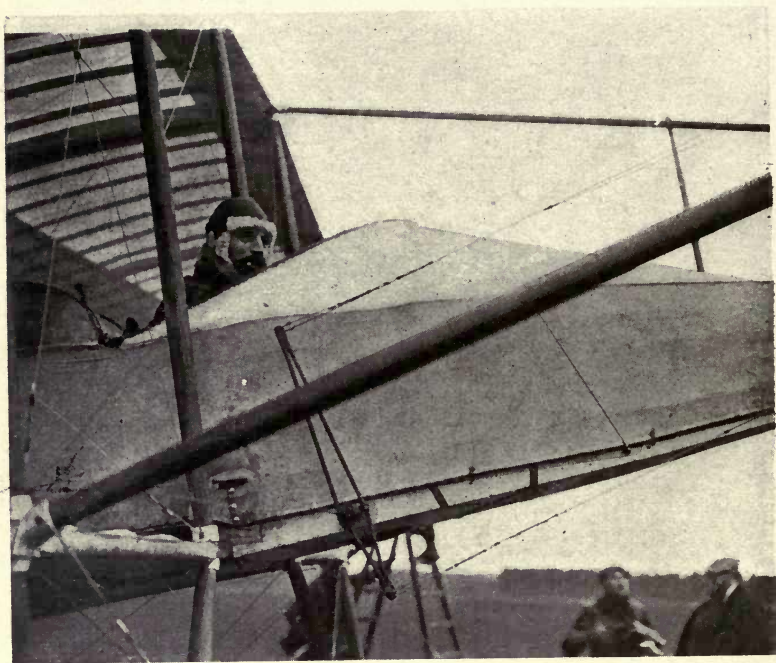
The two small wheels supporting the rear cell are replaced by a single skid. Other characteristics are substantially as given.

The new racing type of Farman has the following characteristics: The surface is reduced to 350 square feet, and the spread to 28 feet. The total weight in flight is about 1,050 pounds. Twenty-one pounds are lifted per horse-power, and 3.0 pounds per square foot of surface. The aspect ratio is 4.2 to 1.

References.—Aerophile, v. 17, p. 220, p. 488; Aeronautics, v. 4, p. 206; v. 5, p. 218; Flight, v. 1, p. 641; Flug Motor Tech., No. 22, p. 10; Boll. Soc. Aer. Italiano, v. 6, p. 288; Locomocion Aerea, v. 1, p. 78; Aeronautics (Brit.), v. 2, p. 117; SCI. AM. SUP., v. 68, p. 324; La Nature, v. 37, p. 329.

8. THE "FARMAN MILITAIRE" BIPLANE (TYPE MICHELIN)

Henri Farman on this machine established the world's record for duration of flight, when on December 18th, 1910, he flew continuously for almost eight hours and a half. This wonderful



HENRI FARMAN ON THE "TYPE MICHELIN," WITH WHICH HE ESTABLISHED A DURATION RECORD OF 8h. AND 23m. ON DEC. 18, 1910, COVERING 288 MILES.

Note the enclosed body and huge fuel tanks.

achievement was really made possible by the great weight-lifting capacity of this type, enabling him to carry almost 450 pounds of fuel in an enormous tank. The "type militaire" is remarkable for its great size, the newly adopted inclosed body, the dihedral angle of the planes, and its three direction rudders. This type is very steady, slow, and capable of making trips that it would

tax many an automobile to make, and that in fact few trains can accomplish. A slightly smaller type has attained great success.

Weyman made his flight from Paris to Clermont, 420 kilometers, in seven hours, on a biplane of this type. Wynmalen made the round trip between Paris and Brussels with a passenger far quicker than the fastest express train, and in many ways with greater security.

Height records, distance records, five-passenger-carrying records, and a great variety of special prizes have been made and won by this type and types similar to it. The slow speed does not at all indicate that the type is inefficient, but on the contrary, makes it far safer and far more serviceable, especially in military work, where hovering over one spot is of great importance.

Almost unlimited are the possibilities of practical utilization in commerce, in war, and in recreation, of a type of this character, capable of flying from sunrise to sunset without ever touching *terra firma*.

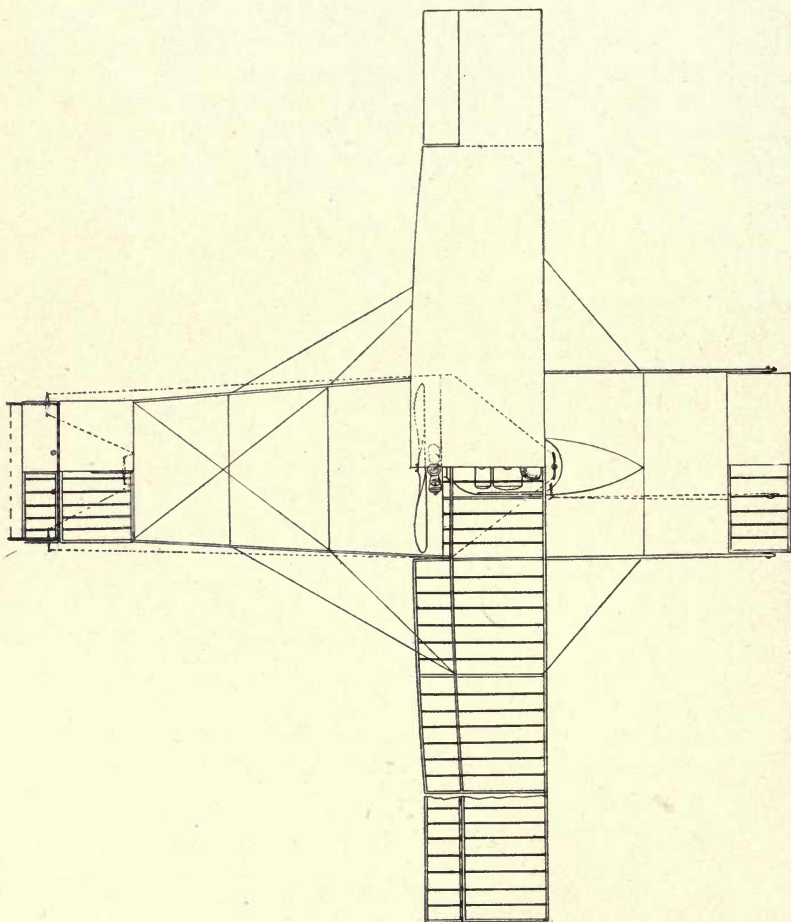
The Frame.—The details of the framework and the general character of the main cell, outriggers, rear cell, etc., are similar to the other Farman types; steel tubing, however is more generally used. A new departure is the introduction of a covered central body, containing the seats, the tanks, etc., and shaped to a stream line form, very much as on the Maurice Farman. The outer panels of the upper plane are hinged and held in place by an inclined movable steel tube strut enabling these parts to be folded down when not in use. This disposition was first installed on the smaller Farman of Fischer.

The Supporting Planes.—As on many of the Farman biplanes of 1910, the lower plane is made shorter than the upper. The spread on the upper plane is $49\frac{1}{4}$ feet and that of the lower 36 feet. The total area is 540 square feet, which makes this the same size as the Cody.

The entering edge of the upper plane is horizontal, but the trailing edge is curved up from the center, thus giving to the upper plane an incident angle which gradually decreases from the center to the ends. This is supposed to increase stability and

lift. The entire lower surface is set at a dihedral angle which is rather large.

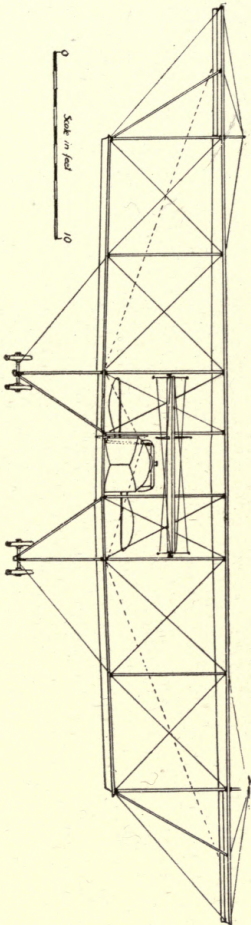
The Control System.—The rudders and controlling system are the same as on the other type—a front elevation rudder com-



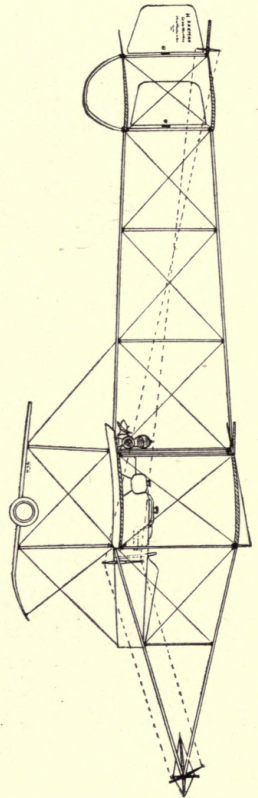
PLAN OF THE H. FARMAN "TYPE MICHELIN"

Compare with the Wright Model R, drawn to the same scale.

bined with the movable trailing flap on the upper surface of the rear cell, and ailerons on the outer ends of the upper main surface. Three direction rudders instead of two are installed.



FRONT AND SIDE ELEVATION OF THE "TYPE MICHELIN"

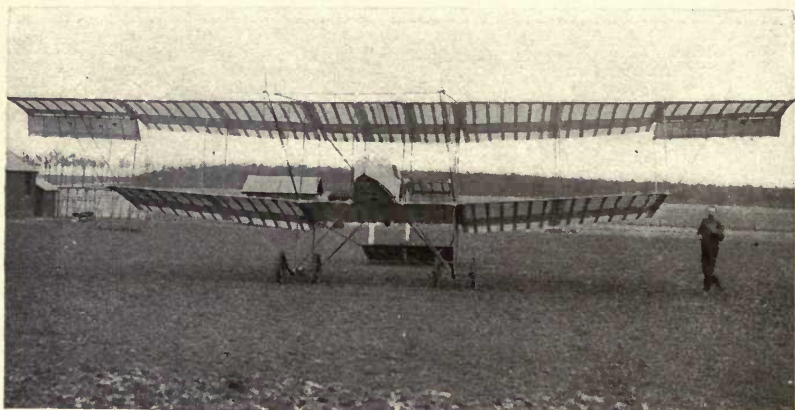


Some of the earlier "types militaires" were equipped with an aileron on each end of the lower panel and two above, making six in all.

The *motion power* is the usual seven-cylinder 50 horse-power Gnome plant, with an Eole propeller.

Weight, Speed, Loading and Aspect Ratio.—

The total weight is from 1,300 to 1,850 pounds. The speed is about $34\frac{1}{2}$ miles an hour; 37 pounds are lifted per horse-power,



FRONT VIEW OF THE "TYPE MICHELIN"

and 3.4 pounds per square foot of surface. The aspect ratio is 6.8 to 1.

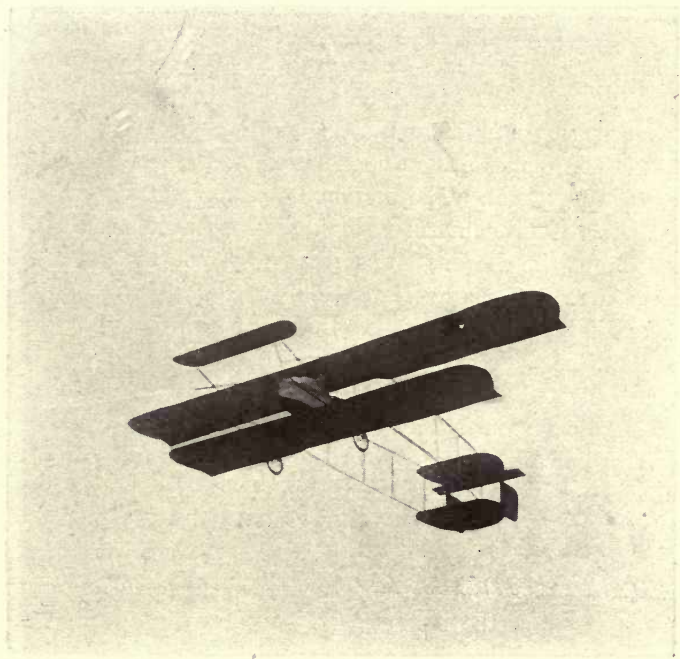
References.—SCI. AM., December 31st, 1910, p. 516; Aero, December 7th, 1910, p. 451; December 14th, 1910.

9. THE MAURICE FARMAN BIPLANE

Early in 1909 Maurice Farman, a brother of the pioneer, Henri Farman, began his career as an aeroplane constructor, rivaling in due time his brother. Although up to the late summer of 1910 they conducted their business separately, the Farman brothers are now working in partnership, the H. Farman and the M. Farman being two types made by the same firm.

The first M. Farman biplane was constructed by M. Mallet and tried at Buc in January, 1909. In this machine the planes were warped, although the general aspect was the same. Since then this type has been greatly refined. It is to-day an excellent and well-

built machine, and has attained conspicuous success. M. Farman has made many notable flights with this machine. Among the other pilots are Lieut. Byasson, who flew from Paris to Chartres and back, the last week in October, 1910. Capt. Etévé and Lieut. Lucas, former Wright pupils, are now flying this type. Only recently,



THE MAURICE FARMAN BIPLANE

Tabuteau Winning the 1910 Michelin Prize.

in the first week of November last, Maurice Tabuteau flew on this machine for 6 hours 11½ minutes at Buc, covering a distance of almost 300 miles. This record was later bettered by Legagneux on a Blériot, and again broken by Tabuteau himself, who, on December 30th, won the 1910 Michelin prize and established the world's

record for distance without a stop by flying 362½ miles in about 7½ hours. No railroad train in the world goes as great a distance without stopping.

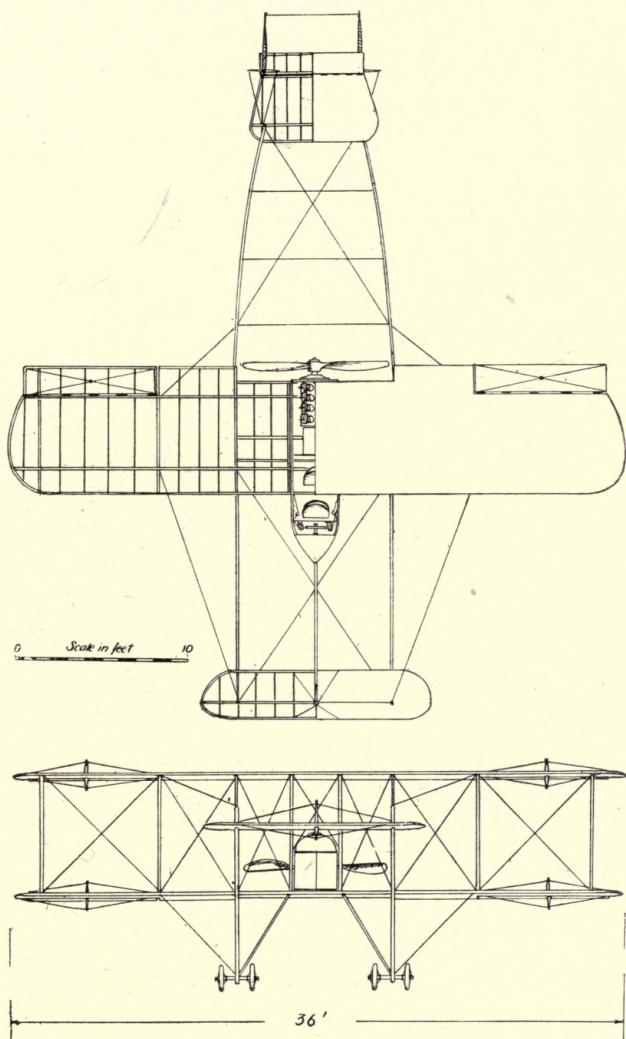
The Frame.—The frame of the main cell is made of the customary wood and crosswire construction. The planes, however, project out in front of the front line of struts, and are not flush with them, as in most biplanes. Outriggers unite the long curved skid to the frame in front, and the cell at the rear is supported on the usual H. Farman-Voisin type framework.

The Supporting Planes.—The main surfaces consist of a frame of wooden ribs and cross pieces, covered above and below with canvas. The planes are curved in plan at the ends, giving a very graceful appearance. The section is exceptionally flat, and lacks altogether the pronounced “dipping edge.” The camber rise is only 1/25 of the chord. The spread is 36 feet, the depth 7.5 feet, and the area 510 square feet.

The Elevation Rudder.—At the front is situated a single-surface elevation rudder. The two horizontal planes of the rear cell have pivoted trailing edges, which are moved jointly with the front elevator. The control is by a rod leading to the front elevator and wires leading to the rear flaps, all connected to the bar upon which the steering wheel is mounted. By pulling in on this bar the front elevator is tilted up and the rear flaps tilted up, so that the machine rises.

The Direction Rudder.—Two vertical surfaces are hinged to the rear struts of the rear cell. These move jointly and serve as the direction rudder. They are moved by the steering wheel and a lever and wire connection. Turning the wheel to the right, clockwise, for example, will cause the machine to turn to the right.

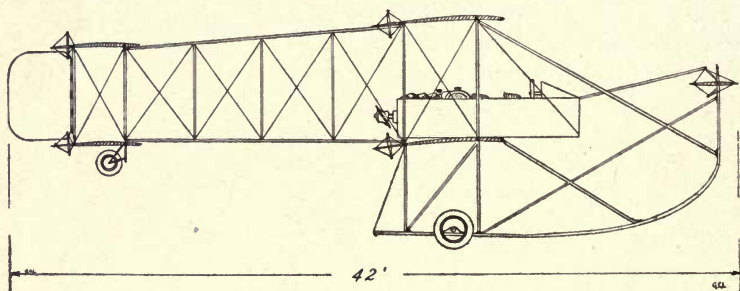
Transverse Control.—The rear edges of both planes are fitted with hinged ailerons; these are controlled by foot pedals, a disposition which has recently been introduced in France and found very instinctive. These pedals are hinged at the base and are pushed down by the feet, very much like the pedals on an organ. Normally the pedals are at a 60-deg. position, and they are held there by a wire leading over a pulley to a counterweight. Springs



PLAN AND FRONT ELEVATION OF THE MAURICE FARMAN BIPLANE

hold all the wires taut. If the aeroplane were suddenly to tip up on the right, the right pedal would be pressed down. By this means the right side is lowered and the left side raised. When making turns, if it is found desirable to use the transverse control, then the pedal on the side to which it is desired to turn is pressed down. The controls, wires, etc., are all duplicate in this machine, to avoid any serious consequences in case of breakage of any part of the steering gear.

Tail.—The horizontal tail planes exert a considerable lifting force. There are no vertical keels. In former machines, vertical panels, "curtains," were used, but they are now eliminated.



SIDE ELEVATION OF THE MAURICE FARMAN BIPLANE

Propulsion.—In general this type is equipped with a Renault eight-cylinder 60 horse-power air-cooled motor. A Chauvière "Integrate" propeller is mounted on the cam shaft. It is 9.8 feet in diameter, 5.2 feet pitch, and revolves at 850 r.p.m. The motor is placed back of the gasoline tank, which is at the rear of the seats.

Seats.—At the center on the lower plane is placed a fusiform frame inclosed in canvas. At the front, well protected from the wind, sits the aviator. Maurice Farman was the first biplane constructor to adopt full protection from the head wind.

A passenger seat is provided at the rear of the pilot, and is also equipped with a steering gear.

Mounting.—The mounting at the front is on two rubber-tired

wheels, fitted to the long curved skids by a rubber spring fastening. At the rear are two smaller wheels. The mounting is especially strong, since the skids are important members of the framework, and transmit the shock of landing over the entire structure.

Weight, Speed, Loading and Aspect Ratio.—

The total weight varies from 1,100 to 1,250 pounds. Tabuteau in his record flight made a speed of 47 miles an hour during the first two hours, and then the speed gradually increased until at the end, he was flying at 51 miles an hour. Twenty-one pounds are carried per horse-power, and 2.35 pounds per square foot of surface. The aspect ratio is 4.8 to 1.

On Tabuteau's machine, the carrying surface was increased in size by the addition of a panel on each side of the upper plane, resembling greatly the construction on the H. Farman "Type Michelin."

References.—Quittner and Vorreiter, *Zeit. für Flugtech. u. Motorluft.*, November 26th, 1910; *Aero*, October 19th, 1910, p. 313; October 26th, 1910; November 2nd, 1910, p. 350. November 23rd, 1910, p. 414; *Flugsport*, October 19th, 1910; *Allgemeine Auto Zeitung*, November 6th, 1910, p. 1; *Aerophile*, February 15th, 1909, p. 81; June 1st, 1910, p. 251; Gabriel, *M. Zeit. für Flug. u. Motor*, November 26th, 1910, p. 287; *Revue de l'Aviation*, No. 41, p. 89; *Revue Aeronautique*, No. 36, p. 197; *Flight*, November 19th, 1910, p. 948; October 22nd, 1910, p. 862.

10. THE GOUPY BIPLANE

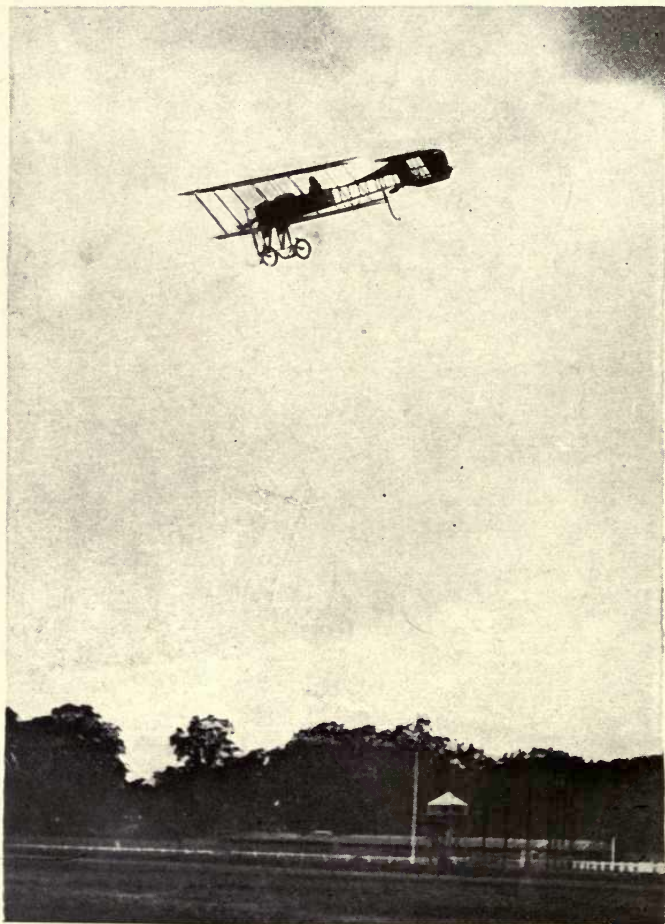
One of the first machines designed by M. Goupy was a triplane with a rear stabilizing cell, built for him by the Voisins and flown for short distances in the spring of 1908.

The Goupy biplane, built in the Blériot factory, resembles the Blériot monoplanes in all the important features of its construction with the exception that instead of one large plane, two smaller planes are used. The original Goupy (1909) was built to the plans of M. Goupy and Lieut. Calderara. It was characterized by a front horizontal rudder, which has since been abandoned, and a four-bladed propeller.

At Rheims, Ladougue on a Goupy won many prizes, and the

Goupy has often exhibited exceptional stability in strong winds.

Frame.—The central frame is of the ordinary Blériot wood and cross-wire construction. The main biplane cell is at the front and at the rear is placed a smaller cell.

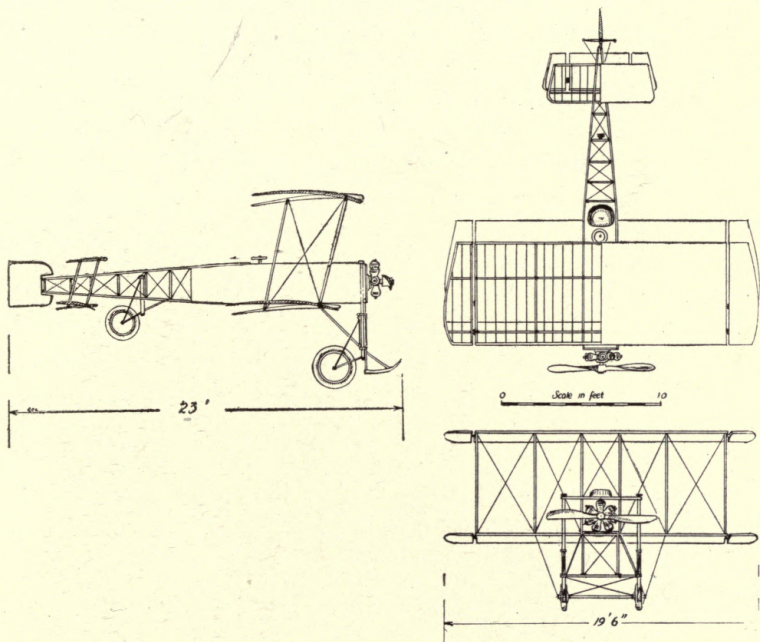


Courtesy of "Flight,"

M. LADOUGNE AT DONCASTER, OCT., 1910; "VOLPLANING" ON HIS GOUPY BIPLANE

Supporting Planes.—The most distinguishing feature of this biplane is the staggering of the main planes, i. e., the upper one is placed ahead of the lower one. It is claimed that this disposition gives increased stability in “volplaning.”

Both the upper and lower planes have ailerons attached at their ends, resembling very much those used on the former



PLAN AND ELEVATIONS OF THE GOUPY BIPLANE

Blériot IX. The curvature is flat, and the planes have a considerable thickness. The spread is $19\frac{1}{2}$ feet, and the depth $6\frac{1}{2}$ feet. The surface area is 237 square feet.

Elevation Rudder.—At the rear of the machine is a horizontal biplane tail. The lower surface of this tail is divided into three parts, the central one being fixed and the outer ones movable. These outer sections move jointly, and resemble the elevation rudder on the Blériot XI. *bis*.

A Blériot *cloche* (explained in full under the Blériot XI.) is provided for control. By pulling back on the *cloche*, the incidence of the ailerons is increased, and at the same time the rear elevation rudder is turned up, so that there is a very strong movement for ascent, the front rising and the rear descending.

Direction Rudder.—A single-surface direction rudder is placed at the rear, and is operated by movement of a steering wheel mounted on the control column. No foot lever is used. To turn to any side the wheel is turned to that side.

Transverse Control.—The ailerons are actuated by the side to side movement of the *cloche*. If the machine were suddenly tipped up on the right side then the *cloche* would be pulled over to the right thus increasing the incidence of the left ailerons and decreasing the incidence of the right ones. This pulls the machine up on the left side and down on the right, thus correcting the equilibrium.

Keels.—The fixed portion of the lower plane at the rear and the small plane above it act as keels exerting a considerable lift. There is also a small tapering vertical keel in front of the rear cell, and the two end panels of the small rear cell are "curtained" with fabric, thus giving two more vertical keels.

The *seat* for the aviator is placed in the frame at the rear of the main cell. A passenger seat is placed well in front of this, over the center of gravity.

Mounting.—The mounting is essentially on three wheels. The two at the front are mounted on the customary steel-tube, rubber-rope spring, Blériot chassis. There is a single wheel at the rear. The front chassis is also provided with two small but very strong skids.

Propulsion.—A 50 horse-power seven-cylinder Gnome rotary motor mounted at the front drives a "Perfecta" two-bladed propeller 8¼ feet in diameter and 4 feet pitch at 1,200 revolutions per minute.

Weight, Speed, Loading and Aspect Ratio.—

The total weight in flight is nearly 1,000 pounds. The speed is 45 miles per hour. Twenty pounds are lifted per horse-power,

and 4.2 pounds per square foot of surface. The aspect ratio is 3 to 1.

References.—Flight, July 16th, 1910, p. 553; December 3rd, 1910, p. 991; Fachzeit. für Flugtechnik, November 13th, 1910, p. 17; L'Aerophile, July 15th, 1910, p. 317; August 1st, 1910; V. Quittner and A. Vooreiter, "Neue Flugzeuge in Paris;" Zeit. für Flug. und Motor, November 26th, 1910. Aero, November 2nd, 1910, p. 350; L'Aerophile, April 1st, 1909, p. 150.

11. THE NEALE BIPLANE

Although similar in general outline and type of construction to the Farman, this new English biplane is radically different in the method of transverse control, in the absence of any rear direction rudder, and in the structure of the surfaces. Many successful flights have been made by the Neale VII., and the odd type of transverse control used appears to work out well.

The Frame.—The framework is similar to the general wood and cross-wire main cell with outriggers now so commonly employed.

The Supporting Planes.—The planes are rectangular, and directly superposed and have an incidence of 9 degrees. They are made of one layer of fabric, sandwiched in between the flat faces of two semicircular ribs screwed together, and considerably cambered. Horizontal cross braces are used under the main spars. This construction gives great strength and is very simple and cheap. The planes have a spread of 34 feet, a depth of 6½ feet, and an area of 400 square feet.

The Elevation Rudder.—A single plane elevator in front, 24 square feet in area, and the trailing edge of the tail surface, are movable jointly, and are controlled by the front and back motion of a universally pivoted control lever (*à la* Farman). To rise, the lever is pulled in.

The Direction Rudder.—The main object in the design of this aeroplane was to construct a machine that could fly across the wind easier than most present machines, which tend to head up into the wind. Hinged to the front strut at either end of the main cell are flaps, or balancing planes called "screens." They are controlled by the side-to-side motion of the lever. These serve the

double purposes of rudders and balancers. They are really brakes, and for steering act as such, merely retarding one side of the machine, while the other "skews" about. If the control lever is pulled over to the left, the left screen is pulled toward the center and thus "brakes" that side.

Transverse Control.—It was found in practice with this machine that a 5 deg. deflection of a screen sufficed for a sharp turn. If the screen on one end was sharply set at 45 deg., however, the machine was found to tip down on that end. This is due to the fact that a large mass of air is screened off suddenly from the planes, and this, with the decreased speed of this end, greatly de-



Courtesy of "Flight."

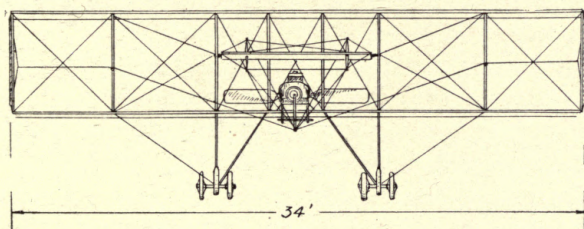
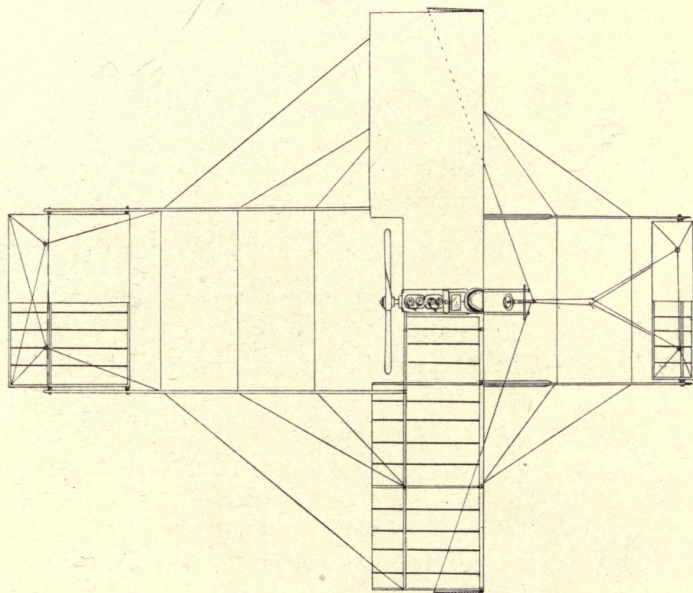
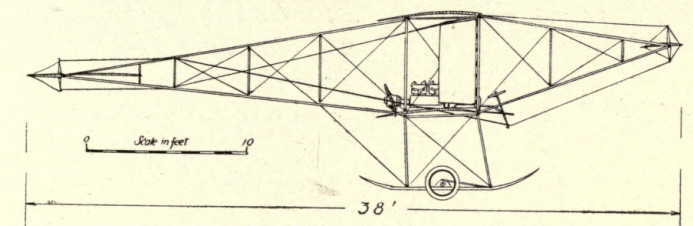
SIDE VIEW OF THE NEALE BIPLANE

creases the lift on this end. The entire success of this operation, however, depends on its suddenness. The screen must be released immediately after deflection, for if held in place air would be drawn in on the other side, and the screening action destroyed. The operation is repeated in quick succession, the required pull on the lever being quite great.

The screen rudders are $12\frac{1}{2}$ square feet in area. A sudden tip down to the left would be corrected by quickly moving the lever several times to the right.

Tail.—There is a single horizontal tail surface at the rear, $52\frac{1}{2}$ square feet in area and having a spread of $10\frac{1}{2}$ feet.

Propulsion.—A 35 horse-power four-cylinder Green engine drives a two-bladed wooden propeller, 7 feet 3 inches in diameter



PLAN AND ELEVATIONS OF THE NEALE BIPLANE

and 4 feet 11½ inches pitch, at 950 revolutions per minute. The motor and propeller are at the rear, the motor being mounted on the lower frame.

A distinctly H. Farman type wheel and skid chassis is used.

Weight, Speed, Loading and Aspect Ratio.—

The total weight is about 1,000 pounds; 281½ pounds are lifted per horse-power and 2.5 per square foot of surface. The aspect ratio is 5.2 to 1.

References.—*Fachzeit. für Flugtechnik*, No. 42, p. 17;
Flight, October 8th, 1910, p. 813.

12. THE PAULHAN BIPLANE

The new Paulhan biplane, actively discussed in aviation circles, is remarkable only for the strength and elasticity of its structure, and the ease with which it can be packed and shipped.

M. Louis Paulhan, whose great exploits as an aeroplane pilot are well known, has here made a happy combination of a new type of construction and the customary disposition of parts in an aeroplane, that is distinctly a step in advance.

Caillé flies this type well.

The Frame.—The frame mainly consists of two lateral girders about 6½ feet apart, placed one over the other, and two longitudinal girders, attached to the lower one. The lateral girders form the entering edge of the main planes, and to them are affixed the numerous ribs. These girders are connected by four huge wooden uprights very wide and thin, fixed by a novel leather joint.

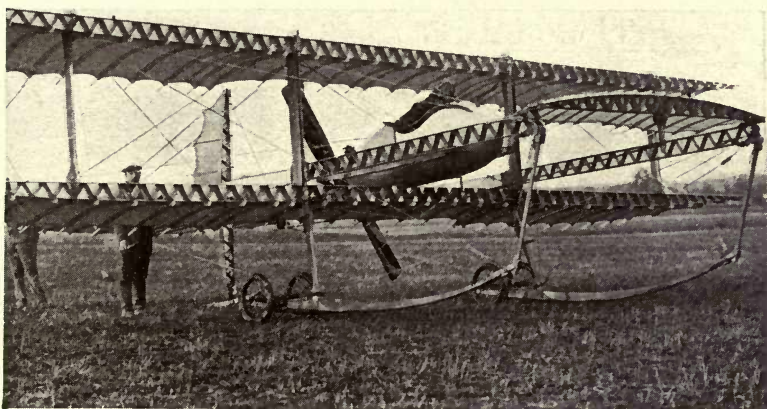
The longitudinal girders carry the elevator at the front, and the rudder and tail at the rear. There is a total absence of cross-wires, the necessary bracing being obtained by the use of a few stout steel cables.

The girders are made of the famous Fabre built-up lattice-work, consisting of two long strips of wood connected by a line of steel triangular plates, the whole giving extremely low weight and resistance as well as great strength.

The Supporting Planes.—The ribs of the planes are very flexibly fixed to the main cross girders by an ingenious clip, which is very easy to remove or replace. In the canvas of the planes

are sewn pockets corresponding to each rib. To put the covering on, these pockets are merely slipped over the ribs and the edges of the material clipped to the front girder and to the rear of each rib. This is an exceptionally practical provision. The surfaces of the planes are very smooth from front to back and are unobstructed by any cross pieces.

The planes have a spread of 40 feet, a depth of 5 feet, and a surface area of 320 square feet.



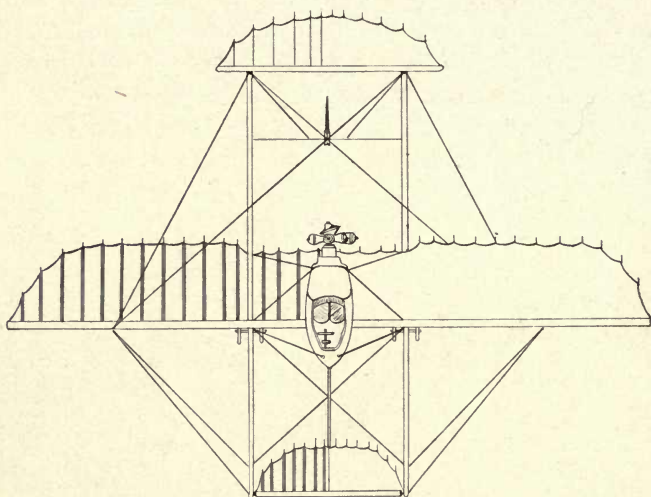
THE PAULHAN BIPLANE

M. Caillé is seated in the nacelle.

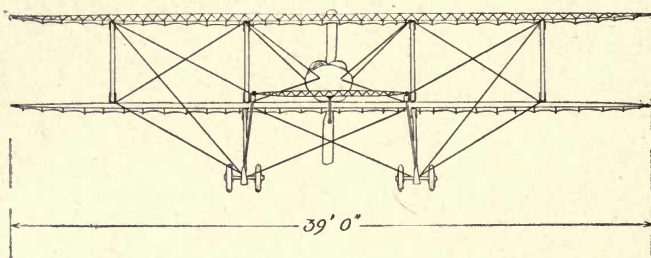
The Elevation Rudder.—The elevation rudder, at the front, is small in size and very strong. It is operated by the forward or back movement of the controlling column, as on the Curtiss and M. Farman.

The Direction Rudder.—The direction rudder is suspended rigidly by cables at the rear just in front of the horizontal *empennage*. It is actuated by the rotation of the steering wheel on the control column, clockwise for a turn to the right, etc.

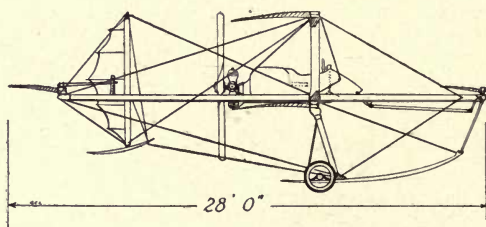
Transverse Control.—The great elasticity of the planes readily permits of their being warped to preserve transverse equilibrium. This is done by the side-to-side motion of the controlling column.



0 Scale in feet 10



39' 0"



28' 0"

PLAN AND ELEVATIONS OF THE PAULHAN BIPLANE

A movement to the left, pulling down the rear edge of the plane at the right, etc.

Tail.—A rear horizontal tail or *empennage* is provided. It is held in place by a lever which can be moved in a slotted bar, and which is locked and unlocked by a key. This enables the incidence of this rear plane to be altered at will and made weight lifting or not, depending on the load to be carried.

Propulsion.—A 50 horse-power 7-cylinder Gnome motor, placed at the rear of the *nacelle*, drives at 1,300 r.p.m. a "Normale" wooden two-blade propeller, 8.9 feet in diameter and of variable pitch.

The Nacelle.—The seats, the steering gear, the gasoline tank, etc., are all inclosed in a fusiform body of aluminum sheeting, called the *nacelle*. This is suspended rigidly from the frame, but in no way rests on it. It is very light, affords great comfort, and is an especially desirable feature because of the ease with which the motor and propeller can be regulated as regards their adjustment and mounting.

The Mounting.—Two very long and strong skids are attached under the main lower lateral girder by heavy uprights, and extend out and up to the elevator. At a point about below the center of gravity a pair of heavy rubber-tired wheels are elastically mounted to the skids. At the rear under the direction rudder is a small skid.

Weight, Speed, Loading and Aspect Ratio.—

The total weight is 950 to 1,050 pounds. The speed is 48 to 50 miles an hour. The aspect ratio is 8 to 1. This is exceptionally high. Twenty-one pounds are carried per horse-power, and 3.28 pounds per square foot of surface.

References.—Aero, 1910, October 26th; November 2nd, p. 350; November 9th; November 16th; November 30, p. 430; "Neue Flugzeuge in Paris," Zeit. für Flugtech und Motor November 26th, 1910; Zeit. für Luftschiffahrt, No. 23, p. 14, 1910; Allge. Auto. Zeit., 1910, No. 44, p. 5; No. 46, p. 52; Flugsport, November 2nd, 1910, p. 675; Flight, October 22nd, 1910, p. 858; Fachzeit. für Flug., November 13th, 1910, p. 15; Aero. (Am.), December 10th, 1910, p. 3; Aircraft, December 10th, 1910, p. 365; L'Aero, November 10th, 1910, p. 2, No. 152.

13. THE SOMMER BIPLANE

IN June, 1909, Roger Sommer purchased a biplane constructed by Henri Farman, and on July 3d he made his first flight. Scarcely a month later he held the world's record for duration of flight, having flown continuously for two and a half hours. His sudden jump into the ranks of the great aviators was unusual and showed that, after all, it was not so hard to learn to fly well. At Rheims and at Doncaster, during the fall of 1909, he won many prizes, but shortly after this gave up flying on the Farman aeroplane and proceeded to design and construct his own. On January 6th, 1910, this biplane was completed and tried out for the first time. M. Sommer at once succeeded in making three perfect flights of several kilometers each, and after three days of experimenting, a long cross-country flight was made. This aeroplane was also operated by Lindpainter and Legagneux.

On December 31st, 1910, the Sommer flew 109 miles in competition for the Michelin trophy, and later, an especially large Sommer established a passenger carrying record.

The Frame.—The materials of construction of the frame are chiefly hickory and ash, steel joints and steel tubing. The general character and appearance of the frame is somewhat similar to that on the Farman machine.

The Supporting Plane.—Two identical and directly superposed rigid planes carry the machine. The surfaces are made of rubber cloth covering wooden ribs. The sectional curvature of the surfaces is not as highly arched as on most other types, but is more nearly as in the Wright machine, a very even and gently sloping curve. The spread of the planes is 33 feet, the depth 5.2 feet, and the surface area 326 square feet.

The Direction Rudder.—The direction rudder consists of a single surface at the rear of 10 square feet area. It is operated by a foot lever, governed by the aviator. To turn to the right this lever is turned to the right, etc.

The Elevation Rudder.—At a distance of 8.25 feet in front of the main cell, and supported on framing carried down to the skids, is situated the single surface elevation rudder. This is gov-

erned by a large lever in the aviator's right hand, which when pushed out turns down the rudder, and when pulled in turns up the rudder, thus respectively lowering and raising the aeroplane.

Transverse Control.—The lateral equilibrium is secured by

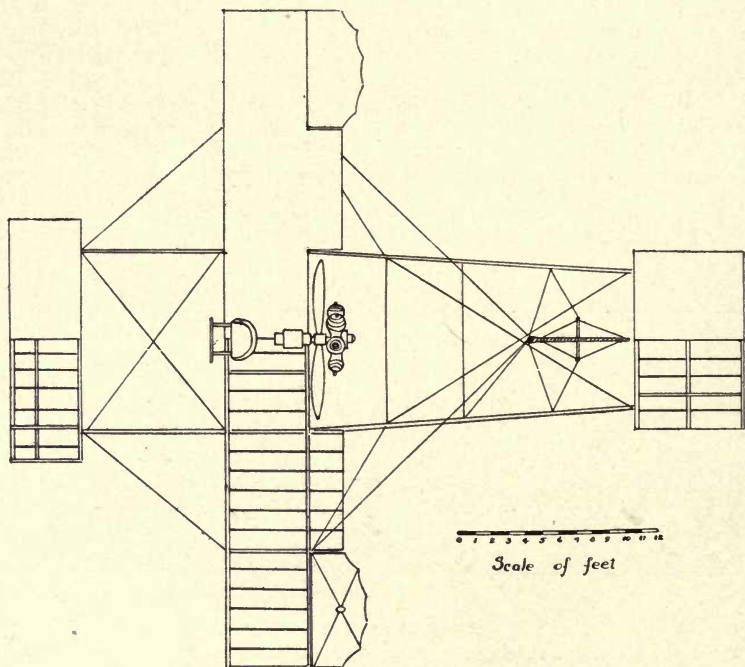
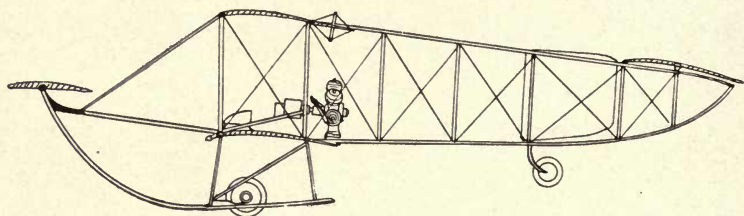


Photo Edwin Levick, N. Y.

THE SOMMER BIPLANE, RACING TYPE

The lower plane is cut away on either side, thus reducing the resistance and enabling the aeroplane to attain a higher speed. Paillette drove this machine with great success at Rouen, 1910.

means of two ailerons, one placed on either end, at the rear of the upper main plane. In distinction to the Farman there are no ailerons on the lower plane. The control is by side-to-side motion of the large lever exactly as on the H. Farman.



0 1 2 3 4 5 6 7 8 9 10 11 12

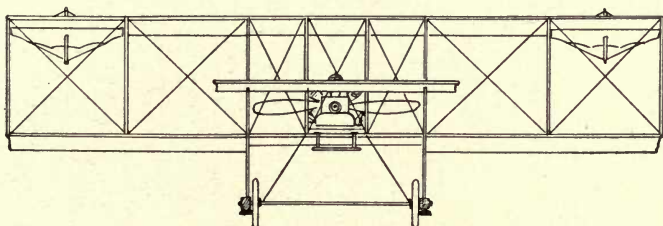
Scale of feet

SIDE ELEVATION AND PLAN OF THE SOMMER BIPLANE

Keels.—A single horizontal plane of 55 square feet area and of very light construction is placed at the rear and steadies the machine longitudinally. This plane is movable, although it does not act as a rudder. A lever at the right hand of the aviator, which automatically “locks,” enables the angle of incidence of this surface to be varied at will, thus increasing the attainable stability.

Propulsion.—A 50 horse-power Gnome rotary air-cooled 7-cylinder motor, placed at the rear of the main cell, drives direct a Chauviere wooden propeller of 7 feet diameter and 5.2 feet pitch at 1,200 r.p.m.

The Seat for the aviator is fitted more comfortably than in



FRONT ELEVATION OF THE SOMMER

other aeroplanes, and is placed on the front of the lower plane at the center.

The Mounting consists of a combination of two large wheels at the front and two smaller ones at the rear. The front wheels are attached by rubber springs to two skids, built under the frame. The skids themselves are attached to the main cell by uprights, the joints being made of a springy sheet of metal bolted to the framing. This adds still further to the extremely springy character of the mounting.

Weight, Speed, Loading and Aspect Ratio.—

The total weight varies from 800 to 900 pounds; the speed is 46 miles per hour; 16 pounds are lifted per horse-power, and 2.76 pounds carried per square foot of surface. The aspect ratio is 6.35 to 1.

Recent Alterations.—For racing purposes the Sommer has recently been altered. The two end panels of the lower surface have been eliminated, very much as on some of the Farman machines. This reduces the area of surface to 256 square feet, and makes the loading 3.25 pounds per square foot.

References.—*Aerophile*, v. 18, p. 61, February 1st, 1910.

14. THE VOISIN BIPLANE (1909)

The Voisin brothers began their activity as constructors of aeroplanes as early as 1905, when they constructed gliders for both M. Archdeacon and M. Blériot. These gliders were successfully operated over water, being towed at high speed and lifted from the water surface by motor boats. In 1906 the Voisins built a motor machine to the design of a young sculptor, the late M. Delagrangé, and subsequently after making a few changes in the design, built a machine for M. Henri Farman which was the first truly successful aeroplane in Europe. The design of this type remained substantially the same, except for the addition of some vertical keels. This type was formerly very extensively used abroad, over one hundred having been manufactured. It is not so widely used now.

The Frame.—The frame is made of ash with steel joints and several parts of steel tubing. It consists essentially of a large box cell mounted on a central chassis, and a smaller box cell attached to it at the rear. The central chassis is really a unit in itself, and carries the wheel mounting, the motor, the seat, and at the front, the elevation rudder.

The Supporting Planes.—The main supporting planes are two in number, identical and directly superposed. They are made of Continental cloth stretched over ash ribs. Their shape is rectangular. The spread is 37.8 feet, the depth 6.56 feet, and the area 496 square feet.

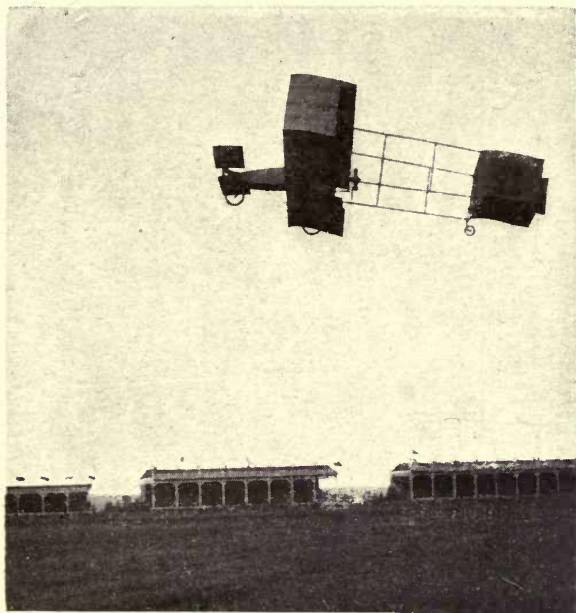
The Direction Rudder.—A single surface of 25 square feet area placed in the center of the rear cells is used for directing the machine. It is operated by a steering wheel and cables as on a boat.

The Elevation Rudder.—The elevation rudder consists of a single surface of 41 square feet area situated at the front end of the

central chassis. It is governed by a lever system attached to the axis of the steering wheel. By pushing out on the steering wheel the rudder's inclination with the line of flight is reduced and the machine descends. By pulling in, the machine is caused to ascend.

Transverse Control.—There is no controlling apparatus for the lateral equilibrium in this type.

Keels.—The two horizontal surfaces of the rear cell about 130 square feet area act as keels to stabilize the machine longitudinally. For steadying the machine transversely and for keeping it to its



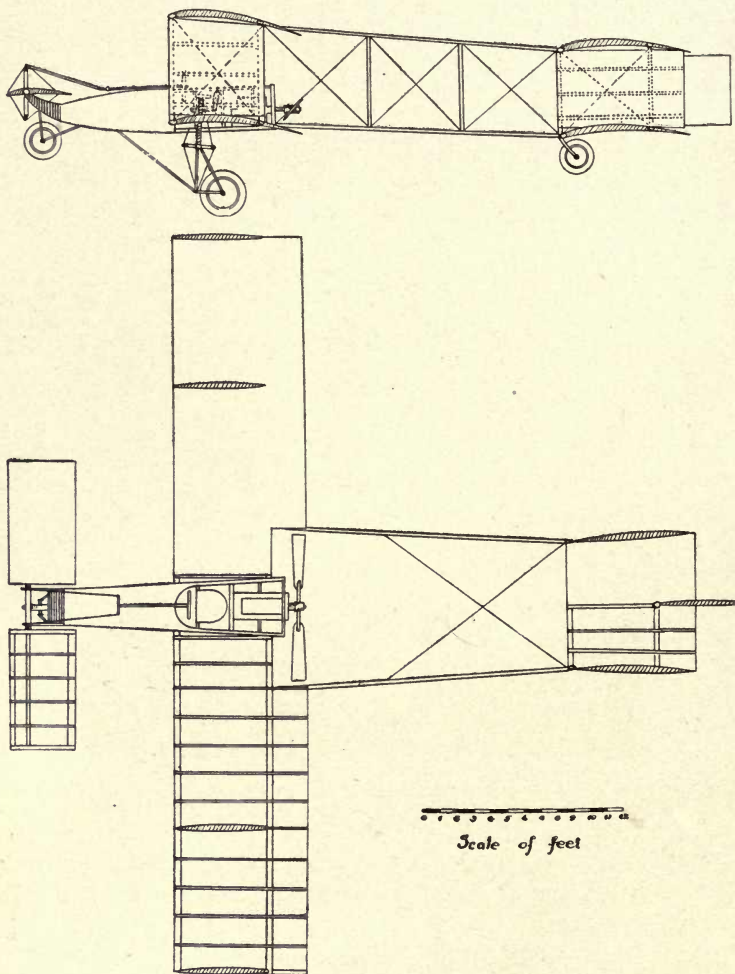
BUXAU-VARILLA ON A VOISIN AT RHEIMS (1909)

course, there are provided six vertical surfaces (two vertical walls of the rear cell and four vertical partitions between the two main supporting planes).

Propulsion.—A 50-55 horse-power motor, placed on the rear of the central chassis, and of the main planes, drives direct a two-

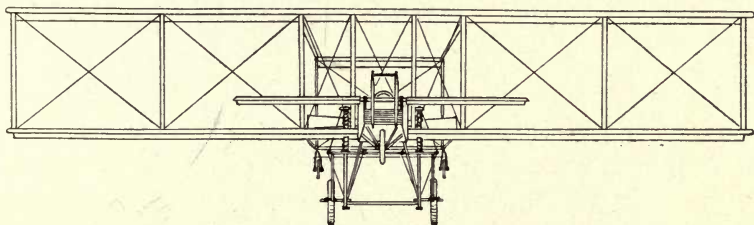
bladed metal propeller, 7.6 feet in diameter and 4.6 feet pitch, at 1,200 r.p.m. Several types of motors have been used.

The Seat is placed on the central chassis in front of the motor and just back of the front edge of the planes.

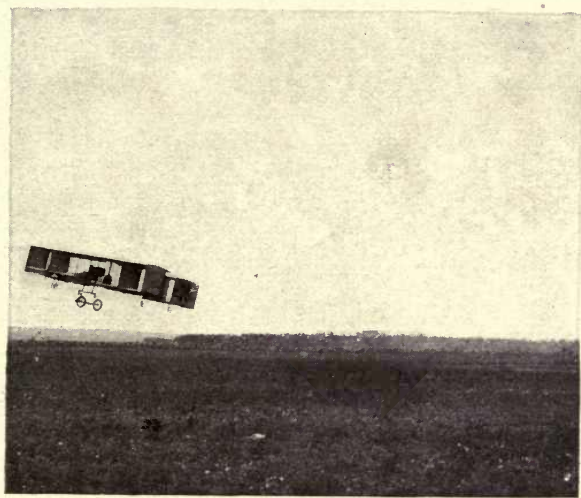


SIDE ELEVATION AND PLAN OF THE CELLULAR VOISIN (1909)

The *Mounting* is on two large wheels fitted with coiled spring shock absorbers at the front and two smaller wheels at the rear. To avoid any disastrous results if the machine should land too much



FRONT ELEVATION OF THE CELLULAR VOISIN



A CELLULAR VOISIN MAKING A TURN

“head on” a small wheel is fitted to the front end of the chassis directly under the elevation rudder.

Weight, Speed, Loading and Aspect Ratio.—

The total weight is from 1,100 to 1,250 pounds; the speed is 35 miles per hour; 23 pounds are lifted per horse-power and 2.37

pounds per square foot of surface. The aspect ratio is 5.75 to 1.

References.—Aeronautical Jour., v. 12, No. 46; v. 13, p. 60; Aerophile, v. 15, p. 232; v. 16, p. 38; v. 17, p. 488; Aeronautics (Brit.), v. 1, pp. 11, 18; v. 2, p. 20; SCI. AMERICAN, v. 97, p. 292; v. 98, p. 92; Locomocion Aerea, v. 1, p. 78; Boll. Soc. Aer. Ital., v. 6, p. 288; Flight, v. 1, pp. 19, 360, 485, 505; La. Tech. Moderne No. 1, p. 5; Soc. des Ing. Civ., v. 2 (1908), p. 13; Zeit. Ver. Deut. Ing., v. 52, p. 956; Vorreiter A, "Motor Flugapparate"; Encyl. d'Av., v. 1, p. 19; Genie Civil, v. 55, p. 341.

15. THE VOISIN BIPLANE (TRACTOR SCREW TYPE)

This machine, built by the Voisins and first experimented with in the late part of 1909, embodied several totally new departures in the construction of biplanes, but had little success. The Goupy and the Breguet, aeroplanes of this type, however, have been flown with great ease.

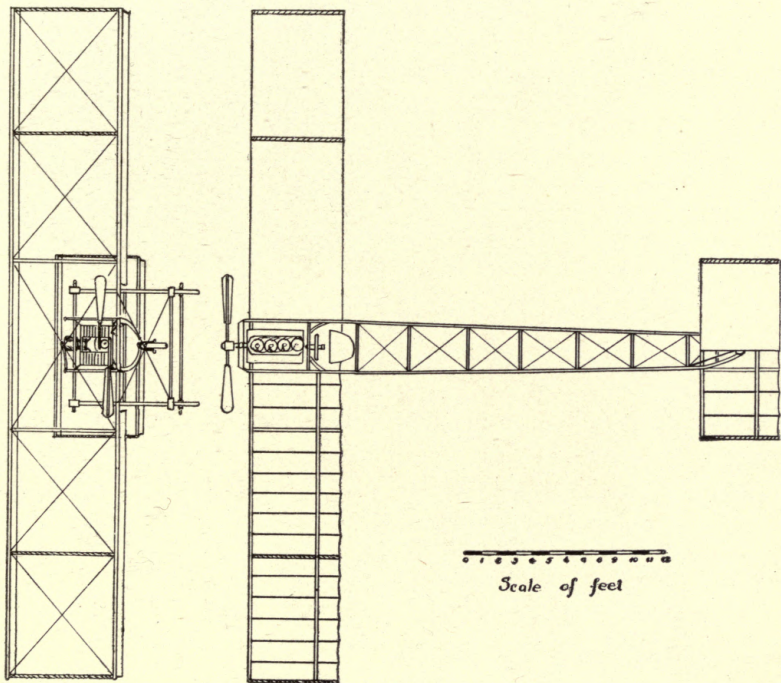
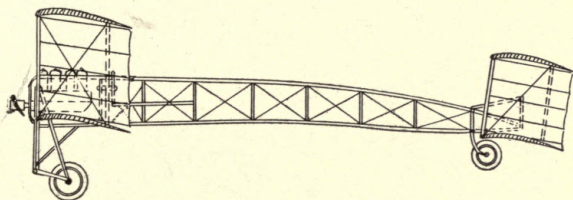
The Frame.—In this type the central chassis extended far out to the rear. At the front were situated the motor and the propeller, and directly behind the propeller was the main cell. At the extreme rear was an auxiliary cell. Ash, steel joints and steel tubing were used throughout.

The Supporting Planes.—The two carrying planes, placed at the front on the central chassis, were identical and superposed directly. Their spread was 37 feet, the depth 5 feet, and the area 370 square feet.

The Direction Rudder and the Elevation Rudder.—The rear box cell was pivoted on a universal joint, and capable of being moved up and down or to either side. It consisted of two horizontal surfaces about 80 square feet in area and two vertical surfaces 50 square feet in area. The vertical surfaces acted as the direction rudder, when the cell was moved from side to side. The horizontal surfaces served to control the elevation when the cell was moved up or down. The movement of the cell was controlled by cables leading to a large steering wheel in front of the aviator. To turn to the right, the cell was turned toward the right. To ascend, the inclination of the cell relative to the line of flight was decreased, the leverage desired being opposite in nature to that of a front elevation rudder.

Transverse Control.—There was no transverse control in this type.

Keels.—Four vertical partitions were placed between the two main planes, as in the other type of Voisin biplane.

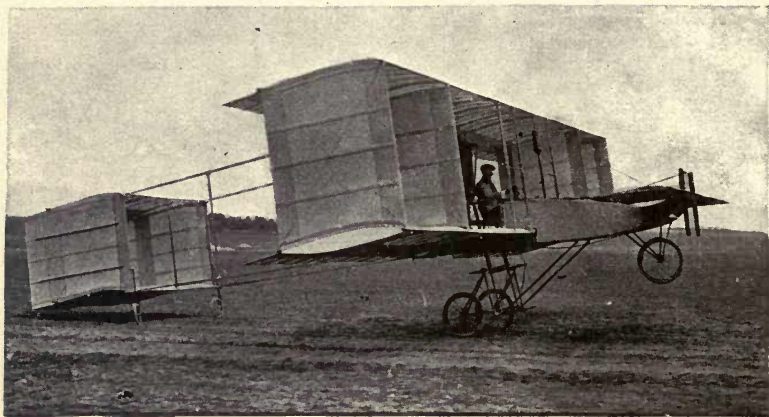


PLAN AND ELEVATIONS OF THE EXPERIMENTAL "TRACTOR SCREW" TYPE VOISIN
The propeller at the front pulled the machine.

Propulsion.—A 40 horse-power 4-cylinder Voisin motor placed at the front end of the chassis drove direct a two-bladed metal propeller of 7.2 feet diameter and 4 feet pitch at 1,300 r.p.m.

The Seat was situated on the central frame at the rear of the main cell.

The Mounting was on two large rubber-tired wheels in front, fitted with shock-absorbing springs and a single wheel at the rear.



A CLOSE VIEW OF A CELLULAR VOISIN

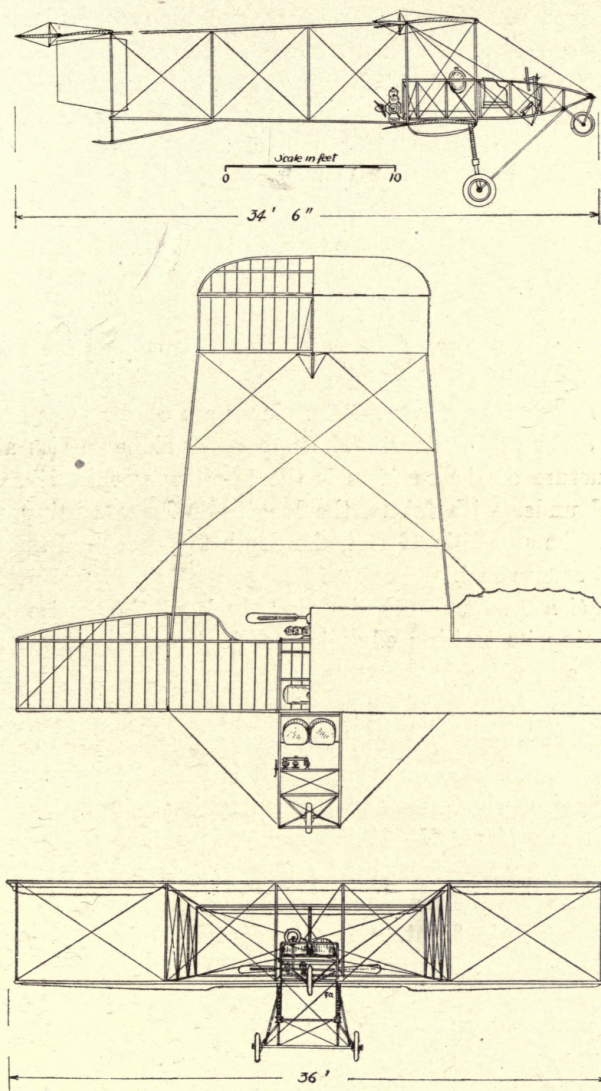
Weight, Speed, Loading and Aspect Ratio.—

The total weight was from 800 to 950 pounds; the speed was said to be 50 miles per hour; 19 pounds were lifted per horse-power, and 2.36 pounds carried per square foot of surface. The aspect ratio was 7.4 to 1.

References.—Aerophile, v. 17, pp. 441, 485; Aeronautics, v. 5, p. 200; Fachzeit. für Flugtech., No. 39, Oct., 1909; Aero., v. 1, p. 347; Genie Civil, v. 55, p. 341.

16. THE VOISIN BIPLANE (TYPE "BORDEAUX")

Although still used abroad, the old Voisin type has recently been replaced by the type "Bordeaux," altogether different from the old type in control, disposition of parts, and structure. The front elevator and the vertical "curtains" are entirely eliminated.



PLAN AND ELEVATIONS OF THE "TYPE BORDEAUX" VOISIN

The front elevator is eliminated and ailerons on the upper plane take the place of the cellular partitions.

The type "Bordeaux" has lately had many conspicuous successes abroad, especially in the hands of Metrot, Bregi, and Bielowucie. The latter made his brilliant Paris-Bordeaux flight on this type.

The type "Bordeaux Militaire," two-seated and equipped with double controlling systems, promises to be one of the most practical of present day biplanes.

The Frame.—Steel tubing is very largely used in the framework, only the ribs and part of the central *fuselage* being made of wood. The main cell carries the usual chassis of steel tubing and *fuselage* at the center. The outriggers to the rear are also very much as on the old Voisin type.

The Supporting Planes.—The planes are of the same span, but slightly different in shape. The upper one alone carries ailerons. The structure of the surfaces is the familiar wooden rib, covered over and under with fabric, the longitudinal spars being of steel tubing. The spread is 36 feet, the depth $6\frac{1}{2}$ feet, and the surface area 395 square feet.

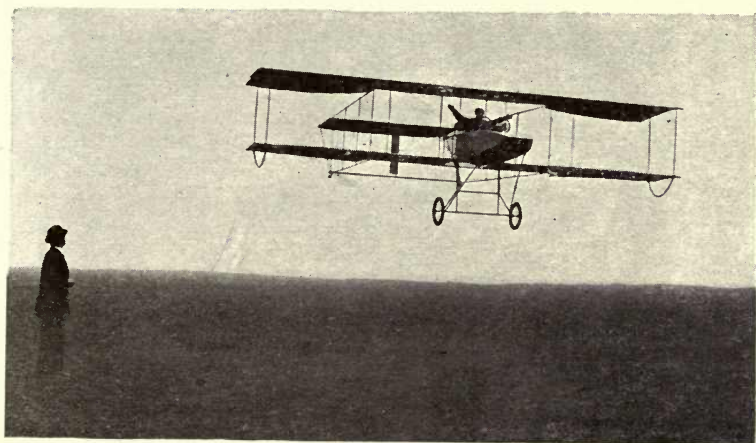
Elevation Rudder.—At the rear, back of the horizontal tail, and forming its trailing edge, is the single-surface elevator, $12\frac{1}{2}$ feet wide and $2\frac{1}{2}$ feet deep. This is operated by the forward and back motion of the controlling column.

Direction Rudder.—Under the horizontal tail at the rear is the single-surface direction rudder, which is turned by the movement of the steering wheel fixed on the controlling columns.

Transverse Control.—At the rear ends of the upper plane are hinged ailerons, $2\frac{1}{2}$ feet chord and $9\frac{2}{3}$ feet wide, which hang down loose when the machine is standing still, and fly out in the air stream when in flight. They are controlled by foot pedals very much as on the M. Farman, excepting that the counterweights are not used.

The two controlling systems installed for the type "militaire" are precisely duplicates of each other.

The Tail.—The rear horizontal tail surface is placed at a considerable angle of incidence, and exerts an appreciable lift. It is $4\frac{1}{2}$ feet deep and $12\frac{1}{2}$ feet wide.

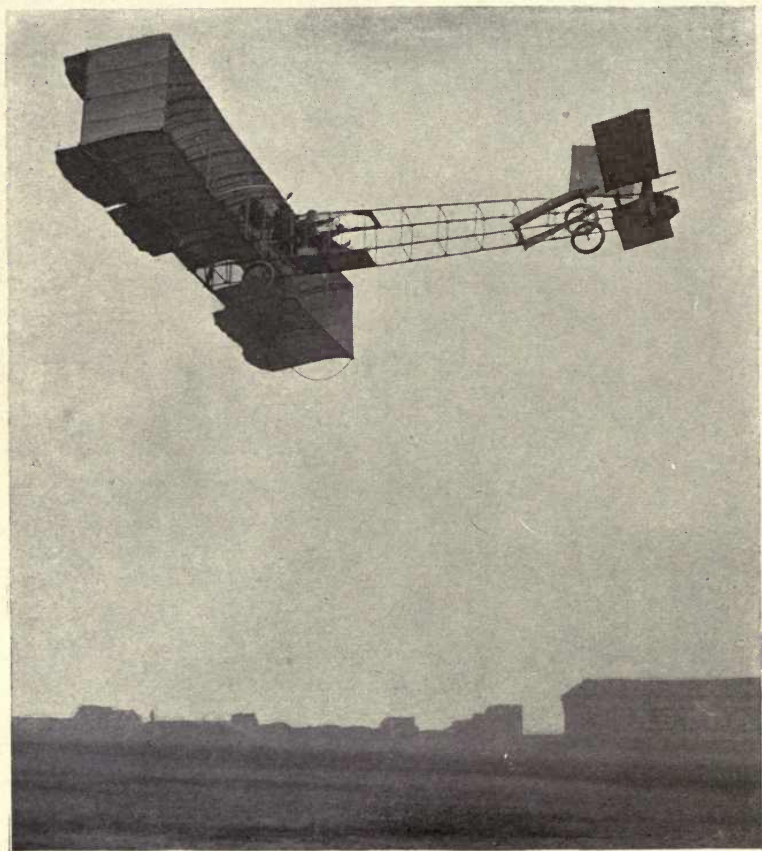


TWO VIEWS OF THE VOISIN (TYPE "BORDEAUX")

The engine is placed very nearly at the center and two sets of steering gear are provided

Propulsion.—At the rear of the central *fuselage* is mounted the motor, which must be of 55 horse-power and weigh less than 440 pounds. E. N. V. 60 horse-power and Gnome motors are largely used. A Voisin two-bladed steel and aluminum propeller, driven at 1,100 r.p.m. and 8.2 feet in diameter, is used.

Mounting.—The mounting is on a steel-tube chassis fitted with two large wheels and coiled spring shock absorbers, under the front



THE VOISIN (FRONT CONTROL, 1911)

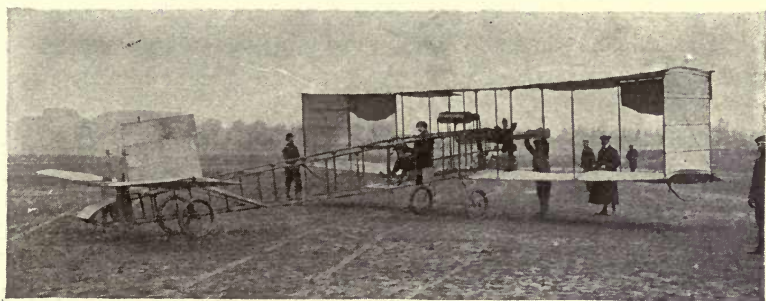
of the cell, a small wheel on the nose of the *fuselage* as a special protection when landing, and two skids at the rear.

Seats.—Two seats side by side are built into the *fuselage* just in front of the main cell. They are exceptionally well placed, and enable the pilot to have a clear view.

The entire machine presents a very simple and finished appearance.

Weight, Speed, Loading and Aspect Ratio.—

The speed is nearly 51 miles per hour. The aspect ratio is 5.6 to 1. The weight varies from 1,300 to 1,550 pounds with full



THE VOISIN (FRONT CONTROL, 1911)

load. Twenty-eight pounds are lifted per horse-power, and 3.14 pounds per square foot of surface.

An added departure in this type is the enlargement of the carrying surface by the addition of a panel on either end of the upper plane, as on the M. Farman of Tabuteau, the Type Michelin, etc.

References.—Allge. Auto. Zeit., No. 42, p. 36; No. 43, p. 3, 1910; Aero, 1910, November 2nd, p. 350; November 30th, p. 432; Fachzeit. für Flugtech., November 13th, 1910, p. 17; Aerophile, 1910, July 15th, p. 318; September 15th, p. 411; Flugsport, October 19th, 1910; Zeit. für Flugtech. u Motor., November 26th, 1910; Flight, 1910, June 25th, p. 486; October 22nd, p. 861.

17. VOISIN BIPLANE (FRONT CONTROL, 1911)

MM. Voisin Frères have constructed a type of biplane, characterized by the absence of a tail and the grouping of the elevation

and direction rudders at the front, carried by a long central *fuselage*. This *fuselage* is attached at the rear to the main biplane cell.

The motor is a 50 horse-power Rossel-Peugeot, and drives direct a two-bladed metal Voisin propeller, at the rear of the supporting planes.

The lateral stability is maintained by means of ailerons operated exactly as on the Voisin (Type Bordeaux).

The main planes have a span of 39 feet, a chord of 7 feet, and an area of 380 square feet.

The mounting is on four wheels, two at the front and two at the rear, fitted with springs.

The aviator sits in front of the main planes in the *fuselage*, and commands a clear view of the rudders and of his surroundings.

This type is experimental, but it has displayed good stability and speed, and rises off the ground very quickly.

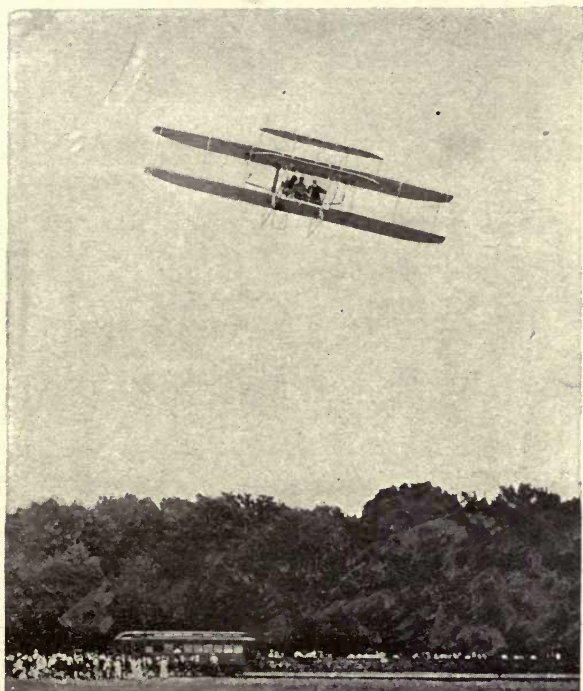
18. THE WRIGHT BIPLANE (1909)

As early as 1903 after exhaustive experiments in gliding Wilbur and Orville Wright made flights in a motor-driven aeroplane differing little from their present well-known type. The first public flights of the Wrights were made in September, 1908, when Orville Wright, at Fort Meyer, and Wilbur Wright, at Le Mans, France, astonished the world with their consummate skill. On December 31st, 1908, the Michelin prize was won for the first time by Wilbur Wright, who on that day flew for 2 hours and 18 minutes. The Wright machine to-day holds no great record except altitude, but the flights of Wilbur Wright at New York in October, 1909, and those of Orville Wright at Fort Meyer in July, 1909, are among the most difficult as yet negotiated. Among the biplanes the Wright is almost twice as efficient in power consumption as any other type.

Many machines of the Wright type are being flown in France, Germany, Austria, Italy, and England, notably by Count Lambert and M. Tissandier in France, Capt. Englehardt in Germany, and

Lieut. Calderera in Italy. In this country the Wright machine has been widely used, by Messrs. Coffyn, La Chapelle, Hoxsey, Brookins, and Johnstone, as well as the Wrights themselves.

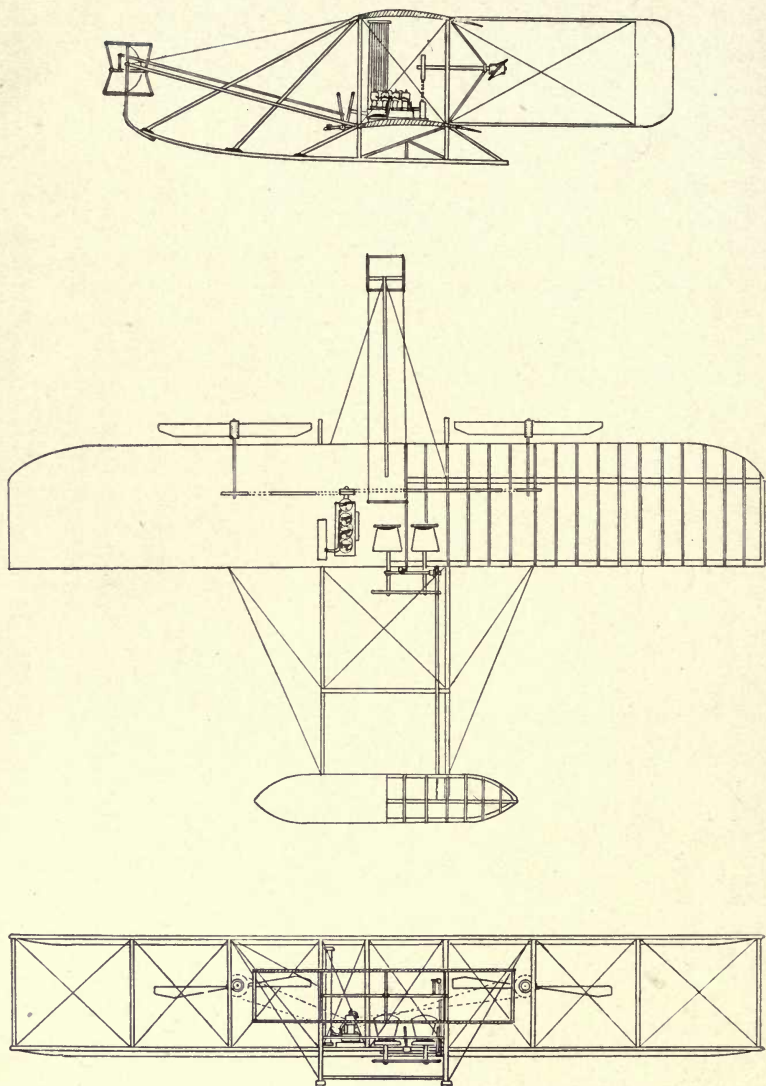
The altitude record is held by the Wright machine, the late Arch. Hoxsey having mounted to the height of 11,400 feet.



ORVILLE WRIGHT AND LIEUT. LAHM FLYING IN THE GOVERNMENT
ENDURANCE TEST AT FORT MYER, VA., ON JULY 27TH, 1909

The old 1909 Wright, although at present almost entirely discarded, was a type that should not be forgotten.

The Frame.—Clear spruce and ash were used throughout the frame, which is very solidly but very simply built. The cross wires were of steel and made to fit exactly. All exposed parts of the frame were painted with an aluminum mixture.



THE 1909 WRIGHT "MODEL A." PLAN AND ELEVATIONS

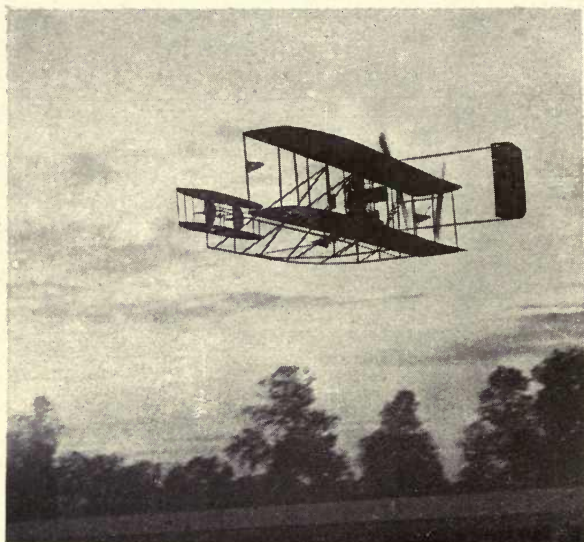
The Supporting Planes.—Two identical and superposed surfaces made of canvas stretched over and under wooden ribs, supported the machine in the air. Their curvature was somewhat flatter than the usual one used, and the surfaces were 3 inches thick near the center. These planes were 6 feet apart; they had a spread of 41 feet, a depth of 6.56 feet, and an area of 538 square feet.

The Elevation Rudder.—In the 1909 Wright biplane the elevation rudder was so constructed that when elevated it was automatically warped concavely on the under side, and when depressed curved in the opposite way. This materially added to the rudder's force. It was double surfaced, 70 square feet in area, and placed well out in front, being supported mainly on framework, of which the mounting skids formed a part. At present the elevation rudder consists of a single surface at the rear. This rudder was governed by a lever in the aviator's left hand. To rise, the aviator pulled the lever toward him. This motion was formerly transmitted to the rudder mechanism by a long wooden connecting rod, causing the rudder to be turned upward to the line of flight, and consequently causing the machine to rise. To descend, the aviator pushed this lever away from him. At present the same control is used, but it is transmitted by wires to the rear.

The Direction Rudder.—The direction rudder was placed in the rear, on the center line, and consisted, as it does now, of two identical vertical surfaces of 23 square feet area. This rudder was governed by the lever in the aviator's right hand. To turn to the left the lever was pushed out, while to turn to the right it was pulled in. But this motion was very rarely used, since the side-to-side motion of this lever also controlled the warping, and the two motions in this type were very intimately connected.

Transverse Control.—The famous warping device was used by the Wrights for the preservation of lateral balance, and for artificial inclination when making turns. The rear vertical panel of the main cell was divided into three sections. The central one was solidly braced and extended either side of the center to the second strut from each end. From these struts the rear horizontal cross

pieces of the planes were merely hinged instead of being continued portions of the cross piece at the center, and the two end vertical panels on either end were not cross braced. These two rear end sections of the cell were therefore movable. The entire front of the machine, as well as the actual ribs inside the surfaces, however, was perfectly rigid, there being no helical torsion of the ribs themselves as commonly supposed. Cables connected these two sections of the planes together and led to the lever in the aviator's right hand. The operation was as follows: If the machine suddenly



DE LAMBERT ON A WRIGHT (1909)

dipped down on the right end, for example, then the lever was moved to the left side. This action pulled down the rear right ends of the surfaces, and at the same time pulled up the rear left ends of the surfaces. This caused an increase of incident angle of the outer end of the plane on the side depressed, and a decrease of incident angle on the opposite side; the consequent increase of lift

on the depressed side and decrease of lift on the raised side righted the machine at once. But throughout this process the entire front face of the cell, as well as the rear central section, remained perfectly rigid in every sense.

For turning to the left for example, it is evident that if this same lever were moved in a circular arc, outward and to the left (very much as a trace of the desired turn) then not only would the surfaces be warped, so as to raise the right end, but also the direction rudder set to give the desired change of direction, and the consequent action was prompt and very efficacious.

In actual practice the direction rudder and transverse control of the Wright machine are almost never worked separately.

Keels.—There were no fixed keels on the Wright 1909 biplane. A small pivoted vertical surface was placed in front to indicate any change in direction of the relative air current.

Propulsion.—A 25-28 horse-power 4-cylinder Wright motor drove by chains, in opposite directions, two two-bladed propellers. These propellers were made of wood, and were placed at the rear of the main cell, one on either side of the center. They rotated at 400 r.p.m., and were 8.5 feet in diameter and of 9-foot pitch.

Seats were provided for two, the outer one for the aviator. They were placed on the front edge of the lower plane to the side of the motor.

Formerly the *Mounting* was on skids only. When starting the machine was placed on a small truck and run over a rail on the ground. At present wheels are used.

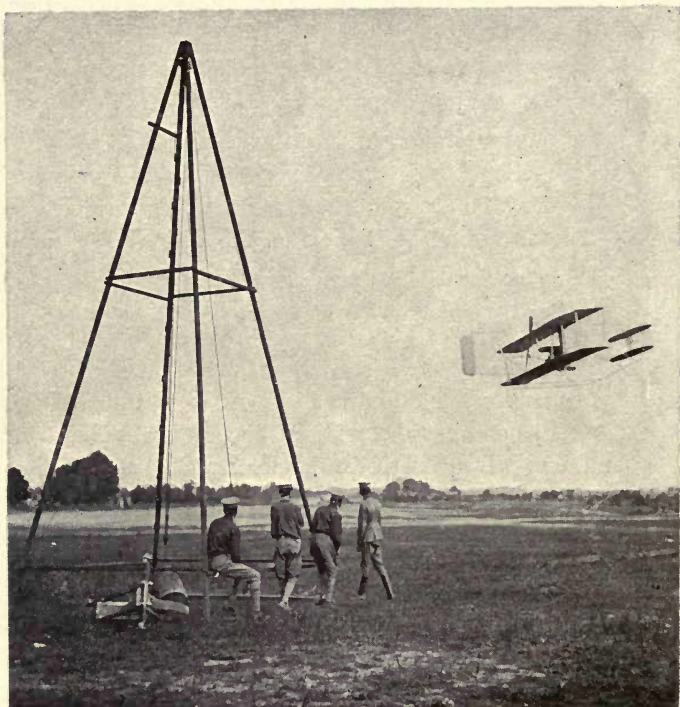
Weight, Speed, Loading and Aspect Ratio.—

The total weight was from 1,050 to 1,150 pounds; the speed is 40 miles per hour; 41 pounds were lifted per horse-power of the motor, and 2.05 pounds per square foot of surface. The aspect ratio was 6.25 to 1.

Alterations.—The dimensions of the United States Signal Corps' machine and that built by the Aerial Company of France differed in that the spread was reduced to 36 feet and the surface area to 490 square feet.

In the French Wright machines of Count Lambert and M. Tis-

sandier, the aviator sits next to the motor. When instructing these two men at Pau in the winter of 1909, Mr. Wilbur Wright had fitted to the machine an extra lever (to control the elevation rudder) on the right side of the passenger who sat next to the motor.



THE WRIGHT MACHINE AT WASHINGTON (1909)

The old derrick and starting rail are shown in the foreground.

The position of the levers for the passenger was therefore the reverse of the usual one, the lever controlling the direction rudder and warping being at the left hand. Tissandier and De Lambert having learned to operate the machine with this disposition have never changed it. But they in turn have become the instructors of many

purchasers of Wright machines, and since their pupils occupy the outside seat, they are taught to control in the normal manner.

References.—Aeronautics, v. 3, Nos. 3 and 4, v. 5, p. 170; SCI. AMERICAN, v. 99, p. 140, 209; Aeronautical Jour., v. 12, p. 114; Zeit. für Luftschiff, v. 13, p. 6; Aerophile, v. 16, p. 470; v. 17, p. 488; Boll. Soc. Aer. Ital., v. 4, p. 410; v. 6, p. "88; Locomocion Aerea, v. 1, p. 78; La Tech. Moderne, No. 1, p. 5; Encyl. d'Av., v. 1, p. 19; Am. Machinist, v. 31 (2), p. 473; Century, v. 76, p. 641; Peyrey, F., "Les Hommes Oiseaux"; Bracke, A., "Const. de l'Aerop. Wright"; Vorreiter, A., "Motor Flugapparate"; Genie Civil, v. 55, p. 342; Zeit. Ver. Deut. Ing., v. 53, p. 1098.

19. THE WRIGHT BIPLANE (MODEL R)

Probably the most interesting aeroplane that has been brought out during 1910 is the small Wright "roadster," with its miniature



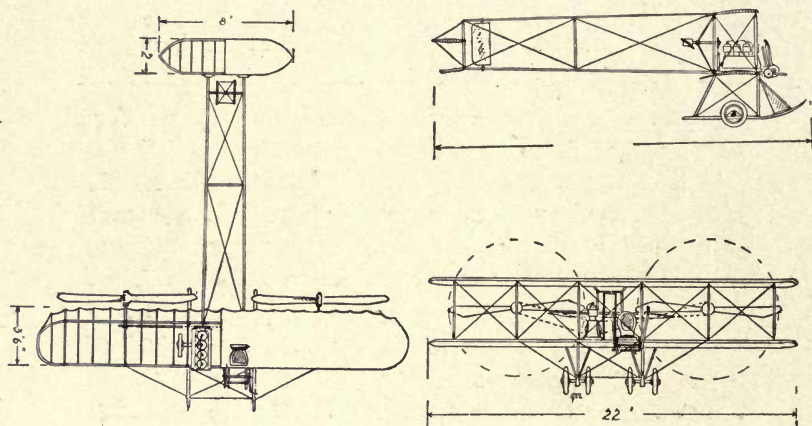
THE SPECIAL WRIGHT GORDON BENNETT RACER

Orville Wright is at the front testing the engine. The propellers are in motion.

biplane cell, and its huge propellers spanning almost the entire machine. This latest speed and reliability product of the Dayton inventors has excited a very lively interest, and without doubt points the way to many of the improvements that the future holds. A machine of this type, but fitted with a 60 horse-power 8-cylinder motor and very much smaller in size, was to be driven in the 1910 Gordon-Bennett Race by Brookins, and there is little doubt, with the phenomenal speed it had already displayed, that it would have won this race from Grahame-White had the unfortunate failure of the engine not occurred.

The regular 30 horse-power type of this machine has, however, proved itself a very good one. Both in speed and in its remarkable ability to gain great altitude, this machine in the hands of Ogilvie, Brookins, and the unfortunate Johnstone, has exhibited far better qualities than many foreign machines using almost twice the horse-power. The speed with which this type can "climb" is exceptional.

The Frame.—The framework follows closely the regulation Wright lines, the outriggers and rudders being similar to the 1910



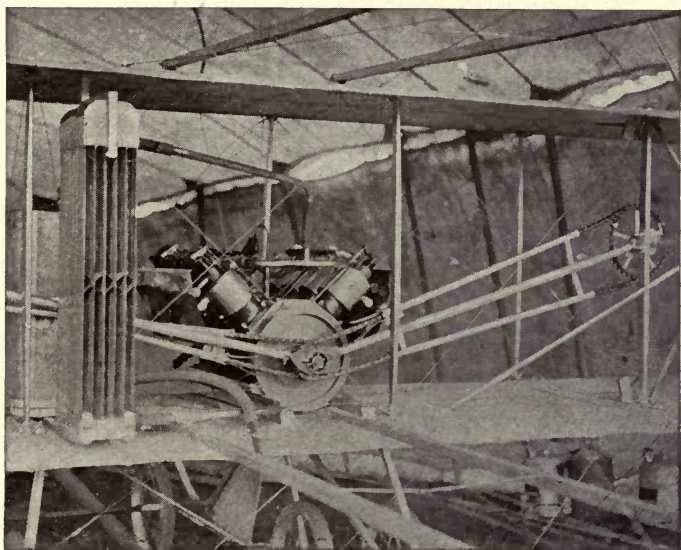
PLAN AND ELEVATIONS OF THE WRIGHT MODEL R, "ROADSTER"

Note the area swept through by the propellers in comparison to the span.

Wright. The skid and wheel mounting, however, is quite different in appearance, although identical in principle.

The Supporting Planes.—The two identical planes are the smallest yet used on an aeroplane. The shape and curvature is as on the other Wright machines, excepting that they project quite a distance out beyond the end panels of the cell. The planes have a spread of $26\frac{1}{2}$ feet and a chord of 3 feet 7 inches. The total area is 180 square feet. On the Gordon-Bennett racer the spread was $21\frac{1}{2}$ feet and the surface only 145 square feet.

The Elevation Rudder.—A single horizontal surface at the rear serves as the elevator, exactly as on the large 1911 Wright biplanes. This surface is 8 feet by 2 feet, and is operated by the new-type Wright control lever placed either on the left or right of the aviator. W. Wright and Brookins, for example, are accustomed to opposite positions. The control lever is mounted on a shaft, and to



THE 60 HORSE-POWER MOTOR OF THE SMALL WRIGHT RACER, AND THE CHAIN DRIVE TO THE PROPELLERS

it is fixed a drum about 6 inches in diameter. The wires for the control are fastened to this drum by short chains, and are thus moved by the lever, a forward movement causing descent, etc.

The Direction Rudder.—The usual biplane direction rudder is used and is operated by the movement of the lever opposite to the elevation rudder lever. By moving this lever and its drum and chain connection forward and back the combination warping and rudder movement is effected, the rudder tending always to steer the machine to the depressed side. The drum upon which the direction

rudder wires are attached is pressed against the lever by a spring and is thus moved with it. In addition, the handle at the top of the lever is made movable and is so connected to the drum that by moving it from side to side, the direction rudder can be operated alone and independently of the warping.

The Transverse Control.—The transverse control is by means of warping, as usual, but the control mechanism, although similar to that used on all the Wright machines at present, is radically different from the old 1909 type.

On the same shaft upon which is mounted the direction-rudder lever and drum is another drum fitted with chains leading to the wires controlling the warping, but in no way connected with the drum to which the direction rudder is attached, except by the spring device as already noted. The operation of the warping is done by the forward and back motion of this lever, and no more by a side-to-side motion as formerly. There is no tail other than the rudders, which in their normal position act as a tail. Two small vertical surfaces on the skid frame at the front are used.

Propulsion.—A regulation 30 horse-power Wright motor is installed, and drives, as usual, by chains, two wooden propellers, 8 feet 6 inches in diameter, at 450 r.p.m. In the "racer" an eight-cylinder 60 horse-power motor drove the propellers at 525 r.p.m. The detail of the propelling mechanism is exactly as on other Wright types.

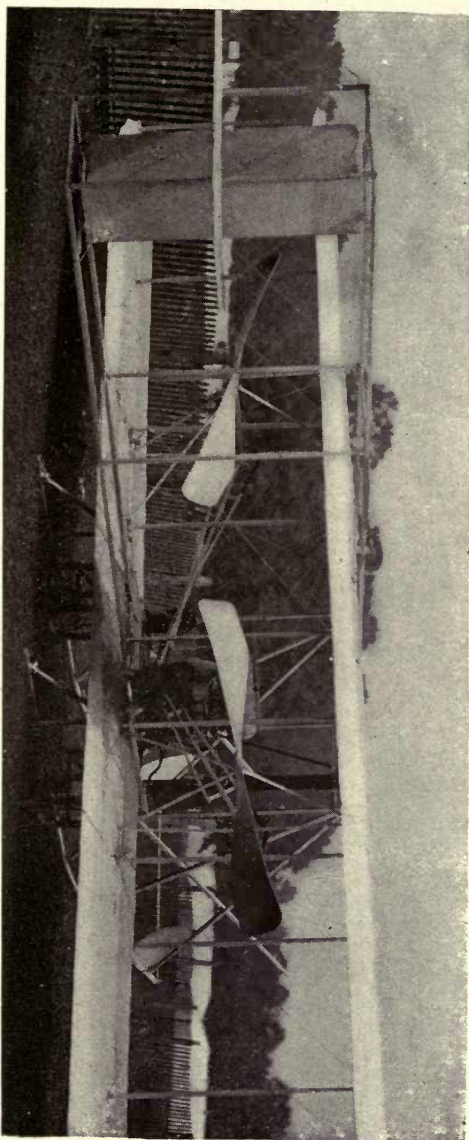
Mounting.—The mounting is on two short skids built down from the lower plane. On each skid is mounted a pair of wheels, the axle being fastened to the skid by a rubber spring arrangement.

On the "racer" two additional wheels were placed in front, making six in all. The chassis on the "racer" appears to have been too weak, but on the "roadster" it works well.

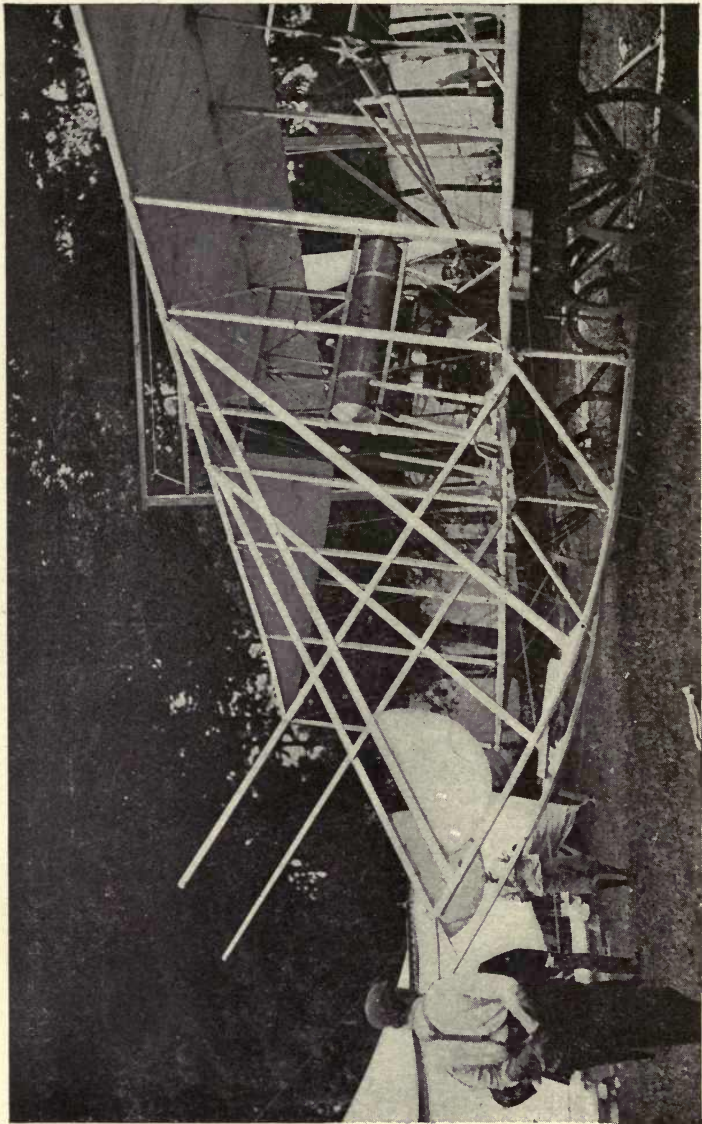
The single *Seat* for the pilot is placed as usual to the left of the motor.

Weight, Speed, Loading and Aspect Ratio.—

The total weight in flight is about 760 pounds, the machine weighing 585 pounds unmounted. The speed of the "racer" has



THE MODEL B WRIGHT
Rear view, showing the propellers and rudders.



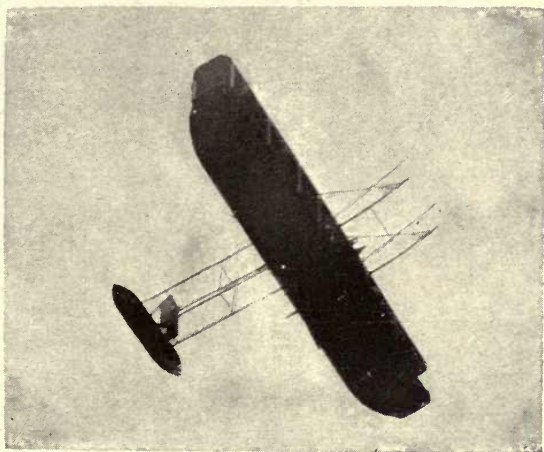
A DETAIL VIEW OF THE MODEL B, FROM IN FRONT, SHOWING THE CHASSIS, SEATS,
MOTOR AND CONTROL LEVERS

been timed by the author at 67.5 miles an hour, and that of the "roadster" at 54.5 miles an hour. Wilbur Wright has stated that even higher speed had been obtained. The pounds carried per horse-power by the "roadster" are 25.4, and 14.3 by the "racer"; the pounds per square foot are 4.20 for the "roadster" and 5.92 for the "racer," the highest loading ever carried on an aeroplane up to the present. The aspect ratio is 7.4 to 1.

References.—Aeronautics, December, 1910, p. 192; Aircraft, December, 1910, p. 363.

20. THE WRIGHT BIPLANE (1911) MODEL B

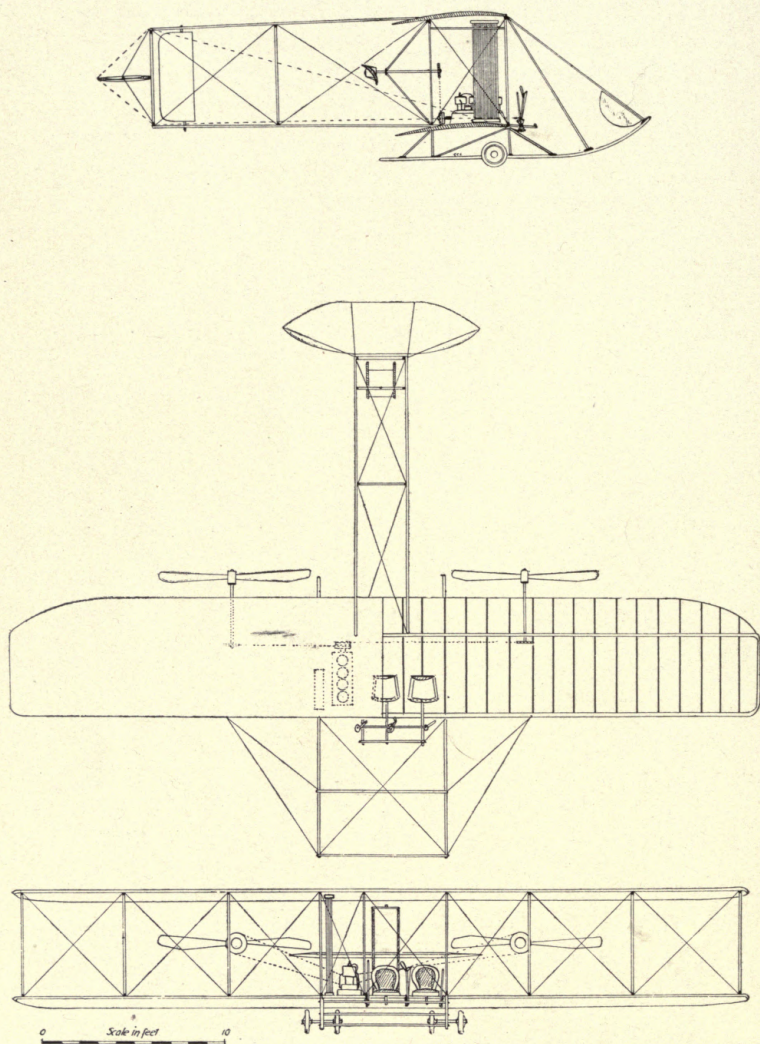
The new Wright passenger biplanes differ from the 1909 type in that the front elevation rudder is eliminated entirely; in its



MODEL B IN FLIGHT

This photograph shows the shape of the planes and rudders as viewed from underneath.

place a small single surface is carried at the rear, and either warped up or down or turned for elevation control, depending on the manner in which it is attached to the frame. The entire machine is resembled closely in appearance by the new "roadster."



PLAN AND ELEVATION OF THE WRIGHT BIPLANE, MODEL B

The type of construction and the disposition of the motor, propellers, etc., is practically the same as on the older types.

The chassis is now fitted with wheels attached to the skids by rubber springs.

The control is by means of the new "breaking" lever system (see p. 288).

The new aeroplanes are smaller and faster than the old ones. The spread is reduced to 39 feet, the depth to $6\frac{1}{4}$ feet and the area to 440 square feet. A 30 horse-power motor is used as usual. Thirty-seven pounds are lifted per horse-power and 2.5 pounds per square foot of surface. The aspect ratio is 6.3 to 1.

On some of the Wright biplanes in Europe, Gnome motors and single propellers have been installed.

PART III.

COMPARISON OF THE
TYPES—CONTROLLING SYSTEMS—
ACCIDENTS—THE FUTURE

CHAPTER XII.

COMPARISON OF THE PROMINENT TYPES

In comparing the successful types of aeroplanes, not only can several interesting contrasts and distinctions be drawn, but conclusions as to the future can be made. For this purpose the aeroplanes are compared according to the following essential features:

- I. Mounting
- II. Rudders
- III. Keels
- IV. Position of seats, motor, etc.
- V. Position of center of gravity
- VI. Transverse Control
- VII. Aspect Ratio
- VIII. Incident Angle
- IX. Propellers
- X. Structure and size
- XI. Efficiency
- XII. Speed and Flight

I. MOUNTING

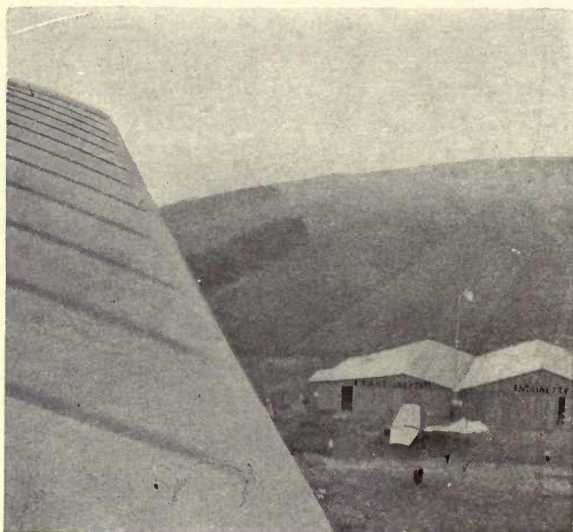
There are three distinct types of mounting:

- (a) Skids alone
- (b) Wheels alone
- (c) Skids and wheels combined

The necessity of providing springs on a heavy machine mounted on wheels has frequently been emphasized. M. Blériot has called attention to the fact that a high speed screw generates a small gyroscopic force which tends to resist all vibration or sudden changes of its axis. If, therefore, when running over the ground the machine be suddenly jarred, the propeller is likely to snap off.

This has often been experienced by M. Blériot himself, and was only obviated by the use of a very springy mounting.

The relative merits and demerits of mounting on wheels or skids are subjects of wide discussion. The advantages of mounting such as in the old Wright machine became very great when starting was to be made from soft soil or rough land, since the rail upon which the machine was placed could be laid down in almost any

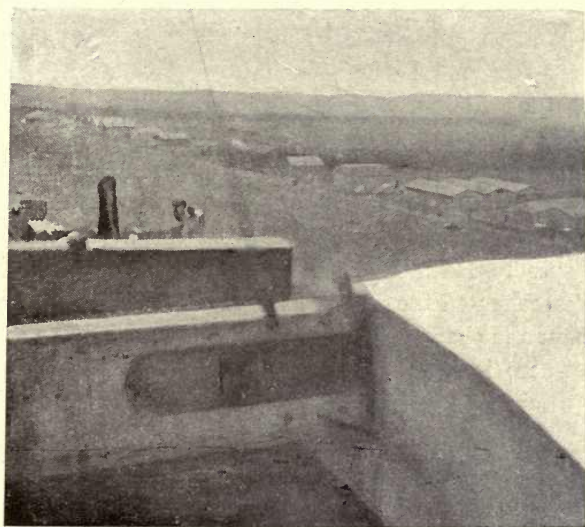


VIEW FROM AN AEROPLANE IN FLIGHT

Photograph taken from the Antoinette in mid-air showing sheds and another Antoinette below. The top of one wing appears in the left of the picture.

kind of country, whereas wheels require a certain area of reasonably smooth and hard ground, a condition not always met with. A machine fitted with skids can withstand rougher landings, and upon alighting stop within a few feet. Furthermore, by using a rail, and, in addition, as was often done with Wright machines, a starting impulse given by a falling weight, a less powerful motor is needed for starting.

Nevertheless, the skid mounting has a great disadvantage in that a machine fitted with them, when once landed away from its starting rail, cannot again take to flight. This has caused skids alone to be disfavored by many aviators. Several combinations of skids with wheels have been proposed and tried, and some of the recent Wright machines have had wheels fixed to the skids to enable a fresh start immediately after landing. These combina-



LOOKING OVER THE BOWS OF THE ANTOINETTE TO THE FIELDS
AND SHEDS BELOW

tions, of which the mounting on the Farman and the Sommer are typical, work with great satisfaction and appear at present to be most desirable for a heavy machine.

The conditions of landing and starting, of course, govern and are governed by the type of mounting used. In landing on rough ground with a Farman type chassis the wheels are likely to catch in brushes, etc., and cause considerable damage. Short Bros., well-known English aeroplane builders, have introduced a chassis on

which the wheels used for starting are made to disappear and landing occurs directly on the skids.

The many different types of rubber rope, steel, and pneumatic springs, are all about equally serviceable. The rubber rope spring introduced by Blériot, is inexpensive, quite durable and very light.

Many of the recent Wright biplanes have not only had the axle of the wheels fitted with a very elastic rubber attachment, but have been equipped with an ingenious device, which enables the aviator to release the axle and cause the machine to rest heavily on the skids, while at the same time small hubs dig into the ground and prevent any motion. Hoxsey, on one occasion, at Belmont Park greatly amused the huge throng watching him return from an attempt at an altitude record, by descending to the ground, near the judge's stand, throttling down his motor, anchoring the machine by the device described above, and walking off to deliver his barograph sheet, while his propellers were turning at quite an appreciable speed. He then returned into the machine, released the "anchor," accelerated the motor, and took to flight.

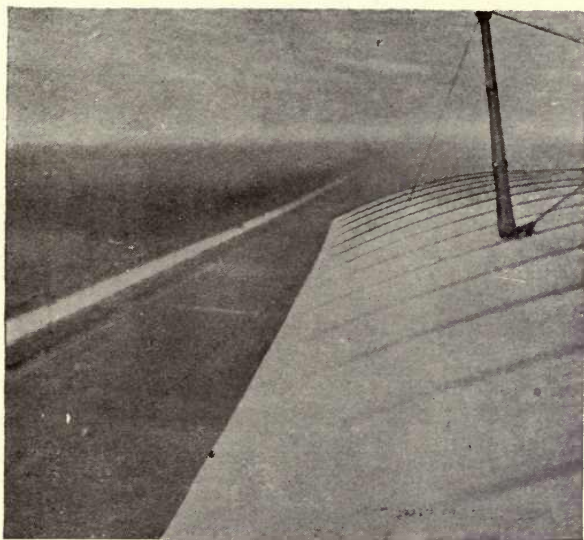
Whatever the character of the mounting, it should be extremely strong. There is little doubt that had the Wright Gordon-Bennett racer, piloted by Brookins, been provided with a stronger mounting, the wreck that occurred would not have been so disastrous. As it was, this machine, carrying an enormously heavy loading, was suddenly deprived of the major part of its motive power, and lost headway. To the author, who was closely observing him as he was passing, barely a hundred feet away, Brookins appeared to be gliding to the ground, with skill and perfect control. As soon as he hit the ground, however, the wheels and skids crumpled like paper, and the machine was almost totally wrecked.

On aeroplanes such as the Curtiss and the Grade, where the loading is light, springy mountings have been found unnecessary.

It is likely, however, that the high speed aeroplane of the future will not only be provided with a very solid, elastic mounting, but will be projected from some ingenious starting device at high velocity so that it may be quickly launched into the air.

II. RUDDERS

The direction rudder in most of the main types is placed at the rear. The 1909 Cody biplane had an additional direction rudder in front, and the Voisin (Front Control 1911) has this disposition. All the monoplanes excepting the new Curtiss, Valkyrie, Blériot "Aero-bus" and Pfizner have their elevation rudders at the rear, while in all biplanes, excepting the Breguet, Dufaux, Goupy,



A ROAD AS VIEWED FROM AN ANTOINETTE IN FLIGHT

and the 1911 Wright and Voisin types this rudder is placed out in front. Rudders placed at the rear are advantageous in that they act at the same time as keels. But in general the placing of the elevation rudder in front appears to offer more exact control of the longitudinal equilibrium.

The elevation rudder almost always exerts some supporting power. Therefore, when placed in front and turned up for ascent, the support is increased as it naturally should be. But when this

rudder is placed at the rear the movement for ascent is such that the supporting power of the rudder is decreased and usually of negative value, so that instead of causing the front of the machine to rise, it merely causes the rear to sink. The same line of argument shows us that when starting, if the elevation rudder is out in front, the front of the machine lifts off the ground strongly and is followed by the body, while if this rudder be in the rear, when turned to give ascent, the rear merely sinks more, and not only is the length of run enormously increased, but the power absorbed and the danger incurred are greater. This is obviously a bad provision. That it is so generally used on monoplanes seems to be caused largely by the placing of the propeller at the front.

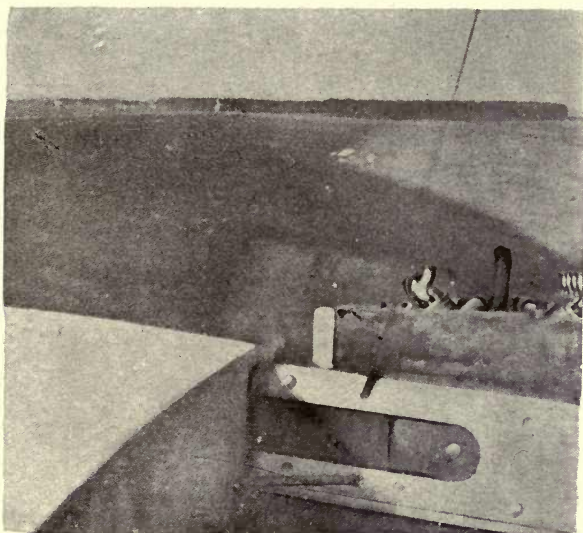
On the other hand, when, as on the (1909) Wright, the elevator is placed forward, it is exposed to the elements, and its great sensitiveness is bad in windy weather. When the elevator is placed behind, as on the monoplanes, it works in the slip stream of the propeller, a region that is turbulent, to be sure, but one in which the air motion is steady and constant in direction. It appears in addition that moving the elevator from the front to the rear of a biplane appreciably increases the speed. Farman designed a biplane without the front elevator many months ago, but has given it up. It is of interest to note, however, that the most recent type of Voisin biplane has both the elevation and direction rudders placed up front.

In some of the Wright biplanes the elevation rudder is so constructed that when elevated it is automatically warped concavely on the under side, and when depressed curved in the opposite way. This materially adds to the rudder's force due to the peculiar law of aerodynamics whereby a curved surface, under the same conditions as a flat surface, has a greater ratio of lift to drift. The reduction in size of the rudder that is thus afforded, and its flat shape, when normal, greatly reduce the head resistance.

In so far as the action of a biplane is usually supposed to cause interference of the two surfaces, and greater head resistance, it would appear as if the biplane rudders as used on the 1909 Wright and the 1909 Curtiss were not as efficient as single planes. But the

structural advantage of this arrangement is great. It is important to note that on the latest Curtiss and Wright machines the elevator is a single plane.

The method used by Glue of only bending flexible surfaces, instead of turning fixed ones, has a great advantage in that the rudders after being used spring back to their normal position. This method has been adopted on several other types, and it has many considerations of safety favoring it.

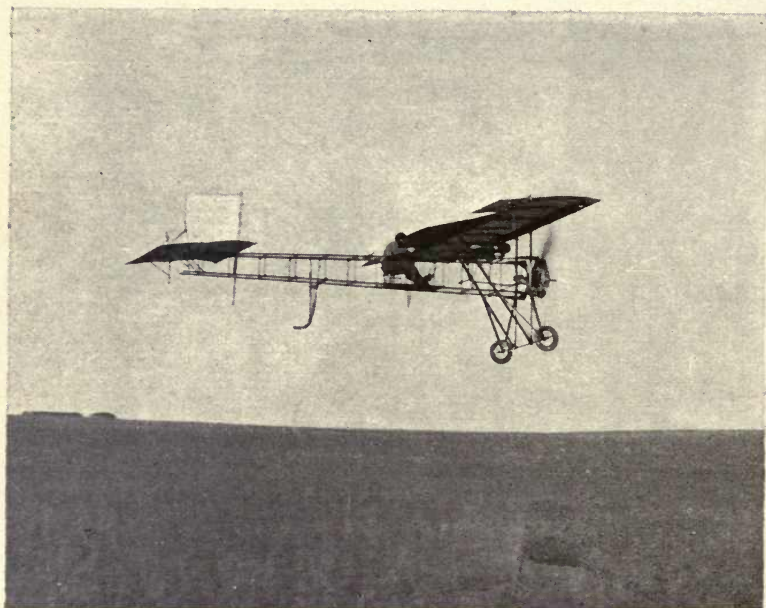


A VIEW IN FRONT, FROM AN ANTOINETTE

The shadow effect is due to the propeller, which is whirling at high speed. The dark band is one of the blades. In the middle distance is a biplane in flight, and in the far distance a patch of woods.

In almost all the aeroplanes that are flying successfully, excepting, possibly, the Wright and the Antoinette, the size of the rudders is generally conceded to be much too great. This is clearly upheld by the usual remarkably small change of inclination of the rudder that is necessary for a change of direction. This ultra sensitiveness where, as in some machines, a movement of a few hundredths

of an inch will considerably alter the state of equilibrium of the machine, is certainly undesirable. To begin with, it need hardly be pointed out that over-sensitiveness of a rudder invites dangerous situations. And, furthermore, if a rudder is extremely sensitive, then it is most likely too big, and if it is too big, then it is ab-



THE FARMAN MONOPLANE EXPERIMENTED WITH IN THE SPRING OF 1910

The Gnome motor and propeller are seen revolving rapidly at the front. The main plane is similar in construction to the Farman biplane surfaces. Ailerons are used for transverse control, and the rudders are at the rear. This machine was found very difficult to control. Note the tense position of the aviator seated back of the main plane.

sorbing power that could be put to better use elsewhere. We may therefore look to a great decrease in the size of rudders as a development of the near future.

For "volplaning," however, as pointed out in Chapter VII., Part I., larger rudders would give added safety.

III. KEELS

Keels on aeroplanes, like keels on a boat, aid in the stability. But on an aeroplane they are "dead surfaces," and as such have the disadvantage of offering greater expanse of surface for wind disturbance to act upon. Furthermore, they unquestionably deaden the motion and decrease the speed. Tapering keels such as used on the Antoinette, Pelterie, Nieuport, Etrich and the latest Blériot XIV., offer a maximum of "entering edge" with a minimum of area, and are for that reason more advantageous than rectangular shaped ones.

Separate keels are entirely absent in the Wright and Santos Dumont. The tapering bodies on the Breguet and many of the monoplanes are a distinct advance.

In the old Voisin type use was made of several vertical keels, partitions, placed not only at the rear, but also between the main surfaces themselves.

Keels add to the resistance of a machine the skin friction and consequent power absorption of such surfaces being considerable, and it is generally conceded now, that control by rudders is becoming so perfected that any inherent stability to be attained by use of keels at the expense of power is hardly worth the while. No special form or combination of keels that have so far been designed and tried have really succeeded in giving any kind of complete inherent stability.

Keels at the rear of a machine somewhat on the order of a bird's tail are nevertheless found advantageous, and we can expect to see such surfaces on aeroplanes for many years to come.

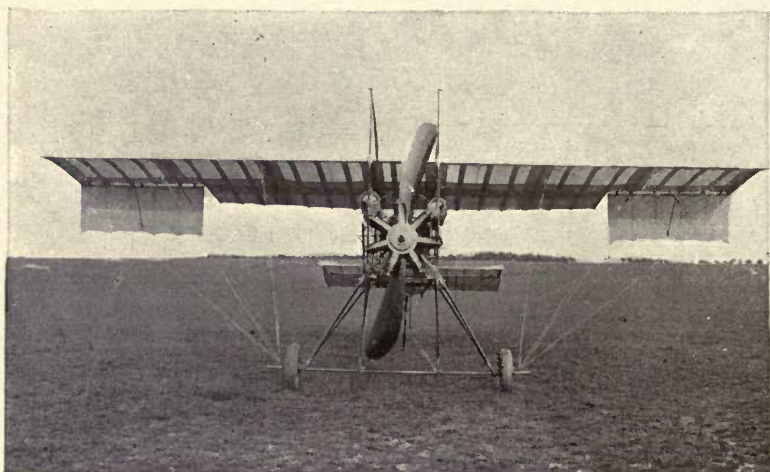
Actual practice shows that they do increase stability and tend to hold the machine to its course.

The reason for this is that they act like the tail of an arrow. If the rear has a high resistance and directive surfaces, and the front is heavily weighted, like the head of an arrow, then the stability is much more perfect. The Antoinette is designed in this way, and in its dart-like flight certainly gives an impression of unusual steadiness.

Many of the present types are equipped with lifting tails. In the Farman, as in many others, the propeller blast causes the tail to lift. This is considered by many to be a bad provision, because if the propeller suddenly stops, the tail at once sinks, and this causes the dangerous condition of loss of headway.

IV. POSITION OF SEATS, MOTOR, ETC.

The position of the seat and the motor is an important point in aeroplane construction. On monoplanes, generally, the seat is



FRONT VIEW OF THE FARMAN MONOPLANE

placed in the *fuselage*, between the main planes and well to the rear. In the Antoinette and the Breguet, the seat is placed in the frame at a point that is deemed the safest, *i.e.*, almost everything else will break before the aviator is touched. On the Wright, Curtiss, Farman, etc., the aviator sits at the front of the main cell. He commands here an uninterrupted view of the air about him, and the land below him.

In the old Antoinette and many of the Blériots provision for seeing clearly below was not made. This was very detrimental,

and the collision that occurred at Milan, when Thomas on an Antoinette, crashed into Dickson's Farman below him, merely because he could not see him, made this defect so patently evident, that the wings of the new Antoinette at once were notched at the rear, so that the aviator could obtain a view of the region below him.

The position of the seat on the Pischof, Blériot XII., and Dornier is advantageous in that the aviator has a clear view below and on every side, can also watch the motor in front of him, and yet is comfortably placed, inside the frame, at a point that is in front of the propeller and fairly safe.



THE CURTISS MONOPLANE BUILT ESPECIALLY FOR THE GORDON BENNETT RACE

It was not very successfully flown. The single plane elevator at the front and the side ailerons for transverse control are clearly seen. Note the similarity to the Curtiss biplane in the chassis construction. The aviator sits in front of the radiator.

The position of the motor at the back of the aviator as on the Curtiss is now generally considered an undesirable one. In case of a sudden plunge to the ground, and a consequent breakage, the motor would fall out of the frame and very likely pin the aviator under it.

Similarly its position above the aviator as on the Grade, Blériot "Aero-bus," and Santos-Dumont is dangerous, in that it would very likely crash through the frame and fall on the aviator's head, if the machine were suddenly to lose headway and sink to the ground.

In many cases aviators strap themselves into their seats, and

the recent tragic death of Moisant, who was pitched head-long out of his seat when the machine suddenly dove down, bears out the wisdom of this measure.

The Maurice Farman and the Voisin were among the first prominent biplanes to have the seats and *fuselage* enclosed, and it is now recognized as quite necessary, especially for long duration flights, to protect the aviators from the head wind. The enclosed *fuselage* of the Paulhan and the new Farman "type Michelin," are as luxurious and as comfortable as "torpedo" body automobiles.

When the propeller is placed at the front there is still more reason for protecting the aviator as the air stream from the propeller is very disagreeable and likely to carry with it fine particles of oil, etc. McArdle in his flight of July 19th, 1910, on a Blériot, because of the film of oil that had formed over his eyes, thought he was in a heavy mist, lost his way, and failed to find the Beaulieu grounds, whither he was bound.

In fact, the provision of a proper degree of comfort for the aviator and his passengers is becoming so important that within a few years we may actually see in use completely inclosed bodies, resembling the cabins on motor boats. Certainly such a provision would enable aviators to guide their aeroplanes to much higher altitudes. A light canvas, aluminum, and mica-glass body shaped in stream line form is looked forward to as a very practical innovation.

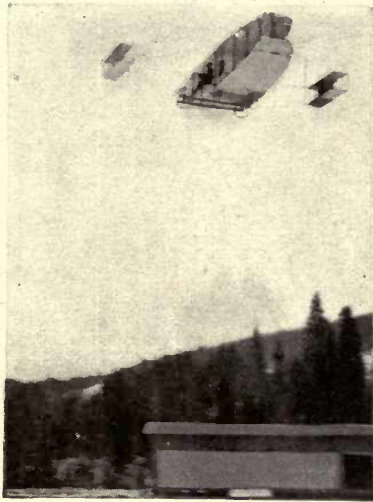
V. POSITION OF CENTER OF GRAVITY

The most advantageous position of the center of gravity is being actively discussed at present, and it appears that no really definite conclusions can be reached. It is recognized in long flights, that the gradual diminution of the gasoline supply affects the equilibrium of the machine, unless the gasoline tank is placed over the center of pressure. On some of the "long-distance" Blériot XI. machines it is deemed necessary to put the gasoline tank low in the frame, in order not to bring the center of gravity too high; this position of the tank requires a pressure feed system. The idea in the new disposition of surfaces on the Farman "Michelin"

seems to have been to raise the center of pressure so as to be able to carry an increased quantity of fuel in the usual position on the top of the lower plane, without any pressure feed to the engine.

The frequent *pique nez* of the Santos Dumont monoplanes, when, on landing, they stand right up on their nose, seems altogether to be due to a position of the center of gravity that is much too high. This, of course, is due to the placing of the motor above the plane.

A low center of gravity, as on the Pischof, is said by some to



THE "BADDECK NO. 2" OF MESSRS.
MCCURDY AND BALDWIN

add greatly to the natural stability because of the pendulum effect, and by others it is thought to be detrimental to turning manœuvres and transverse stability. Actual observation of machines with a low center of gravity in flight shows that they are far more difficult to incline transversely than a machine with the center of gravity about in line with the propeller axis. Machines with the latter provision are easier to handle in almost every way.

The Antoinette is wonderfully well balanced, and the concentration of the weight of the motor at the front, and of the operator in the rear of the main surfaces gives perfect results.

It is doubtless a good provision to have the propeller axis a little above the center of resistance, as on the Wright, because the machine then tends continuously to dive downward, and therefore loss of headway with its serious consequences is not so likely to happen.

VI. TRANSVERSE CONTROL

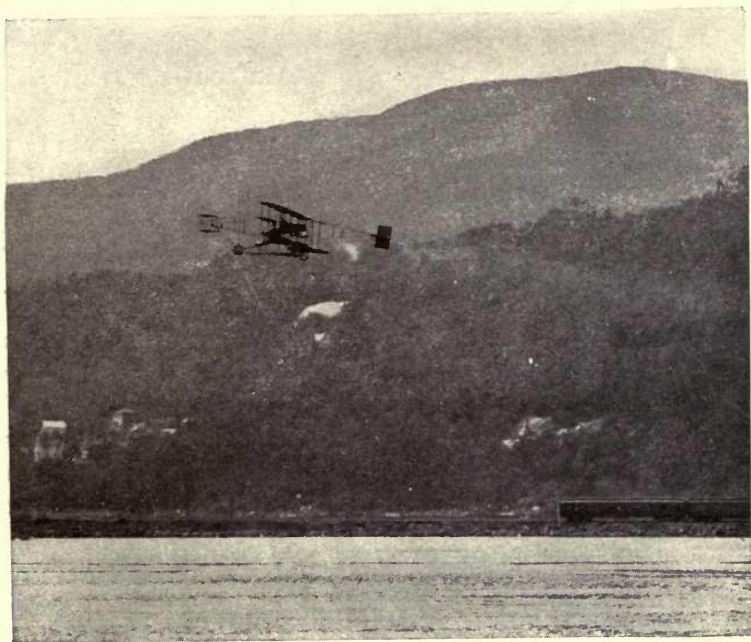
In practice the lateral stability of aeroplanes is mainly preserved in five ways:

- A. Automatically.
- B. By warping of the main planes.
- C. By balancing planes ("wing tips," or "ailerons").
- D. By sliding panels ("equalizers").
- E. By vertical surfaces ("screens").

The old Voisin is the only type for which automatic lateral stability is claimed. The rear box cell and the vertical keels between the surfaces exert such a forcible "hold" on the air that to displace the machine is difficult and in all ordinary turmoils of the air it displays exceptional stability. A well-known aviator amusingly stated at Rheims in 1909 that were a Voisin tipped completely over on one end it would still be aero-dynamically supported, so great is the expanse of vertical surface.

Without such keels, however, the lateral balance of any aeroplane is so precarious that some form of control is necessary. The machines using the methods of warping the main planes for the preservation of lateral balance include in addition to the Wright, Breguet and Paulhan, all the present successful monoplane types except the Pfitzner, Valkyrie, and Blériot "Aero-bus."

Because of the structural difficulty of rigidly bracing the surface of a monoplane, warping is an ideal form of control. But the rigid structure of the biplane permits auxiliary planes (wing tips) to be more easily provided. This is done in the Farman, Cody, Dufaux, Neale, Goupy, Curtiss, Sommer, and the recent Voisin.



TWO VIEWS OF CURTISS ON HIS ALBANY TO NEW YORK FLIGHT

These two methods of transverse control are both very efficacious, but the additional resistance, unaccompanied by any increase

of lift, which is produced by balancing planes, perhaps renders them less desirable than warping. On the other hand, there are objections to weakening the structure of the main surface by making it movable. Wing flexing weakens the spars by constant bending.

Ailerons on the trailing edge if inclined too much are likely to act only as brakes, while ailerons placed between the planes are found to be very inefficient.

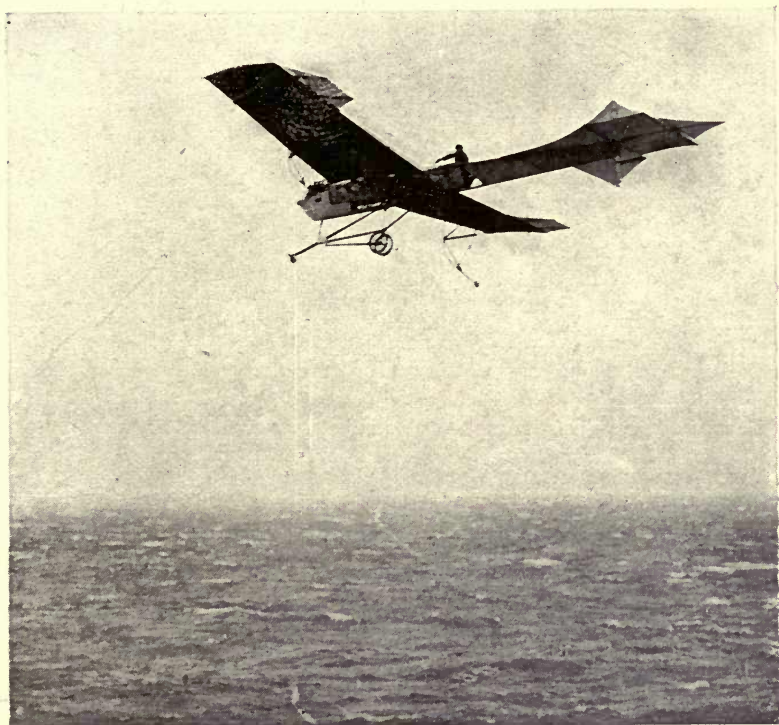
There is a further distinction between these two methods of control which, although not thoroughly understood, appears to be borne out in practice, viz., when a plane is warped the action tends not only to tip the machine up on one side, but also due to the helical form assumed, there is a tendency to turn, which can only be counteracted by a vertical rudder. In the case of "wing tips," however, due to the equal but contrary position in which they are placed, both sides of the machine are equally retarded, and in addition, since the main surfaces preserve the same shape and the same angle of incidence, this tendency to turn appears to be absent. Mr. Curtiss states that for correction of tipping alone he makes no use whatever of the vertical rudder, while the Wright's claim that it is always necessary for them to turn the rudder to the side of least incidence.

Siding panels as applied to the Pfitzner monoplane and "screens" as used on the Neale biplane, represent two of the recently designed methods of transverse control which are thought to be no infringement on the patent rights of the Wright brothers. These systems have not been adequately tried out as yet, but there is no reason why they should not be as effective as the system of warping or the use of ailerons.

There are some other methods designed to give transverse control, and it seems at present that they are all equally reliable. Structural individualities of the types of aeroplanes will in all likelihood persist and we cannot picture the machine of the future with any one kind of transverse controlling apparatus. Wing tips, ailerons, are widely used at present, but further progress in aerodynamics is likely to show us that warping is better.

VII. ASPECT RATIO

It is at once observable from the values given in the tables on page 265 that the ratio of spread to depth (aspect ratio) of the monoplanes is generally less than that of the biplanes. This interesting fact is due very likely to the structural difficulty of making the wing of a monoplane long and narrow, and at the same time retaining the necessary strength without undue weight. The Antoinette builders have lately decreased the depth and



THE OLD "ANTOINETTE IV," PILOTED BY LATHAM OVER THE ENGLISH CHANNEL
ON HIS FIRST UNSUCCESSFUL ATTEMPT TO CROSS

The transverse control was by means of ailerons on this machine.

increased the spread of this type of monoplane, thus increasing its aspect ratio, but the framework had to be greatly strengthened.

The Paulhan biplane has the highest aspect ratio of the present types, and exhibits remarkably good qualities.

Theoretically and experimentally the value of this quantity is known to have much to do with the ratio of lift to drift; but whether or not in actual practice, those machines like the Santos Dumont and Goupy having as low an aspect ratio as 3 to 1 are really inferior in their qualities of dynamic support to a machine like the Paulhan with as high an aspect ratio as 8 to 1, is difficult to determine, since many other quantities such as the loading and the velocity are involved. It is interesting to note here that some of the large soaring birds, notably the albatross, may be considered aeroplanes of very high aspect ratio.

The effect of aspect ratio upon speed is not discernible on comparing the types.

Greater stability, however, is commonly supposed to be given by a high aspect ratio, because of the decreased proportionate movement of the center of pressure.

The advantage and effects of aspect ratio are fully discussed in Chapter VII, Part I. It may be indicated here, however, that another advantage of aspect ratio is that for the same area the decreased movement of the center of pressure causes a smaller maximum moment tending to upset the aeroplane (see p. 82), and therefore permits of smaller rudders being used. It is valuable also to note that experiments in aerodynamics show the drift of planes with different aspects to be about the same, and that the lift alone increases greatly with the aspect ratio.

There is little question that a development in aeroplane construction in the near future will be an increase of the aspect ratio to even as high, possibly, as 12 to 1.

VIII. INCIDENT ANGLE

The incident angle (i. e., the angle, the main inclined surface makes with the horizontal line of flight) varies greatly in the different types. The Wright biplane is noticeable for its low angle of incidence in flight, which rarely exceeds two degrees.

Renard, after deductions from the experiments of Borda, as well as Langley and other investigators, have enunciated the principle that as the incident angle diminishes, the driving power expended in sustaining a given plane in the air also diminishes. Wil-

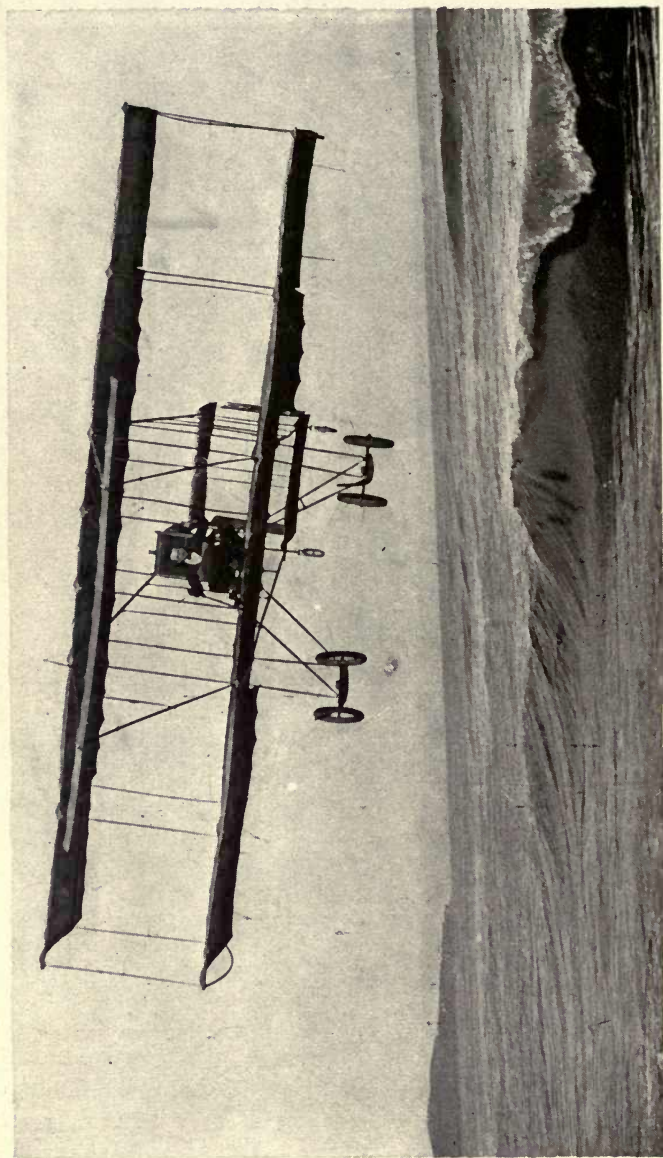
ASPECT RATIO TABLE OF MONOPLANES.

R. E. P. (1911)	6.5	Blériot XI. (Course)	4.5
Sommer	6.2	“ (Cross channel)	4.35
Antoinette	6.	Nieuport	4.23
R. E. P. (1909)	5.75	Hanriot (1 seat)	4.2
Pfitzner	5.17	Tellier	4.2
Valkyrie	5.	Blériot XII.	4.
Etrich	4.72	Pischof	4.
Blériot XI. 2 bis.	4.7	Grade	3.9
Dorner	4.6	Santos Dumont	3.

ASPECT RATIO TABLE OF BIPLANES.

Paulhan	8.1	Wright (Model B.)	6.3
Breguet (40 to 50 H. P.).	7.9	“ (G. B. Racer)	6.3
Dunne	7.6	“ (1909)	6.25
Voisin (tractor)	7.4	Voisin (1909)	5.75
Wright (Model R)	7.4	Curtiss	5.65
Breguet (Course, 60 H.P.)	7.1	Dufaux	5.6
Cody (1911)	7.1	Voisin (Bordeaux)	5.6
Cody (1909)	7.	Neale	5.2
Farman (“Michelin”) . . .	6.8	Farman (1909)	5.
Curtiss (Passenger)	6.4	M. Farman	4.8
Sommer	6.35	Farman (Course)	4.2
		Goupy	3.

bur Wright states that “the angle of incidence is fixed by the area, weight, and speed alone. It varies directly as the weight, and inversely as the area and speed, although not in exact ratio.” Farad concludes that small angles are the most efficient for all aeroplanes. There is for each aeroplane a most efficient angle of incidence where



DURAY AT NICE, APRIL, 1910

A remarkably clear photograph of a Farman biplane.

the power expended for flight is least. In flight the incidence should be kept constant at this value in order to obtain the highest speed.

The Farman, Voisin, Blériot, Grade, and Sommer have an angle of incidence when first starting much greater than when in flight. Since this involves greater drift resistance and consequently more power necessary to attain the velocity of levitation, and, furthermore, in view of the fact that aeroplanes with as heavy a loading but no excessive angle are able to rise after a reasonably short run, it would appear as if this provision were unnecessary.

There exist wide variations in this angle as observed and recorded for the different types, many of the present machines preserve their equilibrium during comparatively large changes of their longitudinal inclination.

In general the incident angle of the monoplanes is greater than that of the biplanes. The most common angle is in the neighborhood of 5 to 7 degrees. But in the Blériot "Aero-bus," an incident angle of 12 or 13 degrees is often used in flight.

Incidence will very likely be established purely by the lift-drift ratio of a plane, and the incidence kept as constant as possible to give this its highest value.

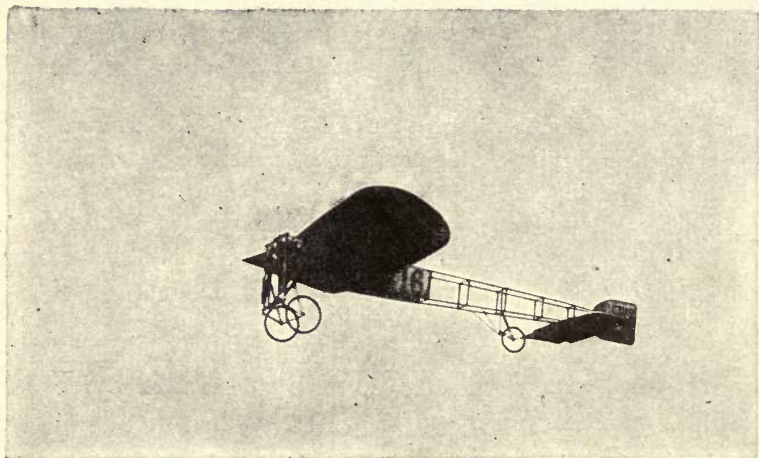
IX. PROPELLERS

Most of the aeroplanes are equipped with a single small high-speed screw.

The Wright and the Cody are the only machines provided with two propellers rotating in opposite directions. The greater efficiency of a propeller of large diameter and slow revolution over one of small diameter and high rotative speed has attracted much attention. This seems to be borne out especially in the case of the Wright machine, in which more thrust is obtained per unit of power than in any other type. The limit of rotative speed in practice is in the neighborhood of 1,500 r.p.m., and in most types the r.p.m. exceeds 1,000. Many of the aeroplanes use Chauviere wooden screws, for which an efficiency of 80 per cent is claimed. Metal propellers are not used much now.

The thrust and efficiency of the various propellers are about the same for equal sizes, and although the theory involved in the propeller is very little understood, the experimental methods used have enabled the design of propellers of as good or better efficiency than those used in marine practice.

The position of the propellers at the front in most of the monoplanes is largely a matter of convenience of design. The swiftly



DELAGRANGE ON HIS MONOPLANE (1909)

This was one of the first Blériot machines to be equipped with a Gnome rotary motor, and Delagrange's death was probably due to the fact that the frame was not strong enough to withstand the greater forces due to the higher power and speed.

moving mass of air from the propeller, however, exerts an added lift when thrown back on the plane. At the same time this action increases the resistance; but as the frame resistance of the monoplane is much less than that of the biplane, the propeller can be placed in front without very serious consequences. The Voisin (tractor type) was the first biplane to have the propeller at the front, and the results with the Breguet and Dufaux, indicate that this is in no way detrimental to the speed.

It is generally believed by aviators that much better results

could be obtained by the use of propellers of 15 or 20 feet diameter rotating slowly. But there are two disadvantages involved in this feature of construction which makes its adoption in the machines of the future rather doubtful. The first is the greatly added weight of so big a propeller and the second the difficulty of building a good chassis high enough to permit of the propeller's rotating freely.

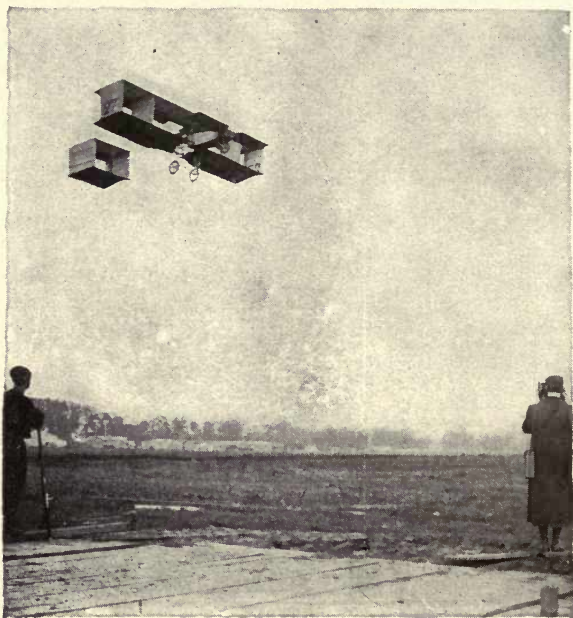
X. STRUCTURE AND SIZE

Most engineers are impressed with the fact that in general the structural features of present-day aeroplanes are "amateurish." This is no doubt well founded in many cases, and aeroplanes have been built and are now building of so flimsy a character that aviators should be forbidden by law to fly them. But when the details of a well-designed and constructed type like the Antoinette are examined, the excellence of the workmanship is at once apparent.

The general type of aeroplane structure is certainly capable of immense improvement and modification. The primary reason for the more or less backwardness in this respect, is that the greater part of the thought and time of constructors has been spent on motors. Now, however, motors are becoming rapidly a secondary consideration. Any number of good ones are on the market, and many of them work with perfect satisfaction for months.

The Fabre type of construction as used on the Paulhan (explained on p. 210) is a distinct step in advance, as is also the metal construction of Breguet. During the past year the use of steel tubing and stronger metal parts has become much more prevalent, and the era of the all-steel aeroplane with riveted or pin-connected joints, I-bar and T-bar struts and spars, and thin steel sheeting for the planes is not far distant. In monoplanes for example, a steel central frame, with two tension members bracing the planes to it below, and two compression members above, forming a rigid truss, would be slightly heavier to be sure, but still ever so much stronger than the steel ribbon and cross-wire structure now used, with tension members above the plane, in many cases inactive and useless when the machine is in flight.

The size of aeroplanes varies in the different types, but between limits that appear well marked. The "waist-pocket" aeroplane is a phantasy, and the one hundred passenger machine is still in the dim future, although it has possibilities of success. The compara-



PAULHAN ON HIS VOISIN, OCT., 1909

tive diagrams of the aeroplanes (see Part II) give an insight into their relative sizes, in far better fashion than words can do.

XI. EFFICIENCY.

One of the best indications of the general efficiency of an aeroplane is the amount of weight carried per unit of motive power. This quantity is usually termed the "pounds per horse-power," and is arrived at by dividing the total weight of the machine in flight by the horse-power of the motor. In the Tables on p. 274 and p. 275

the pounds per horse-power for each type are given numerically and in order of magnitude.

The Blériot XI. (racing model) appears at present to be the most wasteful of power, while the 1909 Wright was by far the most efficient. It must be borne in mind, however, that the Blériot is much faster than the Wright. The Grade, Sommer, Dufaux.



BLÉRIOT ON A CROSS-COUNTRY TRIP

The very flat nature of the country over which so many of the French aviators make extended flights is evident.

Wright (racer) and Santos Dumont, appear also to be inefficient in this regard.

The Dorner, Nieuport and Breguet rank high, as do also the Farman passenger machine, the Antoinette and the Voisin (Bordeaux).

There is no special variation of this quantity with size, however, and it can only be pointed out that those machines using a high angle of incidence appear to be the most wasteful of power. The Wright has the lowest incidence, and utilizes its power best. But the use of two propellers instead of one in the case of the Wright, has probably much to do with its power economy. Less pounds are lifted per horse-power by the faster machines, but their speed, in itself, is a factor of efficiency.

There is also no general distinction between the monoplanes and the biplanes as regards the weight per horse-power.

A more direct indication of the aerodynamic qualities of the aeroplanes is the lifting power of the planes. This quantity, termed the "pounds per square foot" or "loading," is arrived at by dividing the total weight by the area of the sustaining planes, and represents the number of pounds carried per square foot of the surface.

A machine carrying a very light loading, however, is not necessarily inefficient, since many quantities such as the velocity, the height it is desired to attain, and other questions of design, enter into the determination of this loading.

As regards speed, the loading can theoretically be taken as a direct indication of speed, because the heavier the loading, the greater is the speed necessary for support.

There are many surfaces, however, that appear to be more efficient than others, in that they can carry much more loading without decreasing to any great extent the ease with which the aeroplane can take to flight.

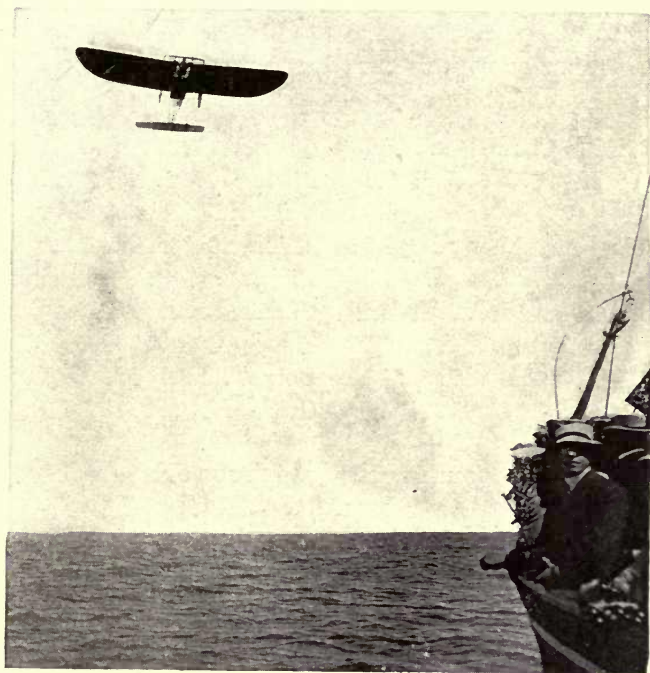
The effect of heavy loading on the landing of the aeroplane is naturally to make the landing shock very great. In the case of the Wright (racer), which had the heaviest loading, it was necessary in order to avoid this shock, to keep the propeller running at full speed even when alighting. This condition is undesirable and requires a large area to land in.

The machine with heavy loading when in actual flight, however, is less likely to be affected by slight pulsations of the air, since it tends more to cut through them because of its small buoyancy.

A heavily loaded machine cannot soar or glide as well as a

lightly loaded one, nor can it rise to as great a height. This is a distinct disadvantage, especially in view of the recent high flying and what it augurs for the future in the way of soaring with motor cut off for long stretches of time and at great elevations.

Another bad effect of heavy loading on an aeroplane is the difficulty it has of starting in a wind; and the ease with which lightly



BLÉRIOT IN MID-CHANNEL

loaded aeroplanes take to flight in squally weather was especially noticed at the recent aviation meetings.

Heavy loading, however, involves also the question of economy, since less material need be used, and the design can be made more compact.

In the Tables on page 274, the loading for each type is given numerically.

The Grade and the Wright have the lightest loading, while the Blériot XI. (racer) and the Wright (racer) have the heaviest. It is particularly noticeable that in general the monoplanes are more heavily loaded than the biplanes, the Grade being an exception. This, however, is not accompanied by any generally remarkable high-speed qualities of the monoplanes, as would be expected, but is probably due to the interference in lifting of the surfaces of a biplane with each other.

TABLE OF POUNDS PER SQUARE FOOT OF SURFACE.

MONOPLANES

Blériot XI. (Course) . . .	5.76	Sommer	3.8
“ XII.	5.3	Pischof	3.65
R. E. P. (1911)	4.6	Valkyrie	3.5
Blériot XI. (cross channel) . . .	4.5	Antoinette	3.33
Nieuport	4.5	Etrich	3.2
R. E. P. (1909)	4.4	Pfitzner	3.2
Hanriot (1 seat)	4.15	Santos Dumont	3.1
Blériot XI., 2 <i>bis</i>	4.1	Dorner	3.
Tellier	4.	Grade	2.

TABLE OF POUNDS PER SQUARE FOOT OF SURFACE.

BIPLANES

Wright (G. B. Racer)	5.92		
Breguet (Course 60 H.P.) . . .	5.4	Cody (1910)	2.8
Breguet (40 to 50 H.P.) . . .	4.4	Sommer	2.76
Goupy	4.2	Cody (1911)	2.8
Wright (Roadster)	4.2	Curtiss	2.5
Curtiss (Passenger)	3.64	Neale	2.5
Farman (Michelin)	3.4	Wright (1911)	2.5
Paulhan	3.28	Voisin (1909)	2.37
Dunne	3.2	“ (tractor)	2.36
Voisin (Bordeaux)	3.14	M. Farman	2.35
Farman (Course)	3.	Dufaux	2.1
“ (1909)	2.8	Wright (1909)	2.05

TABLE OF POUNDS PER HORSE-POWER FOR MONOPLANES

Dorner	39.	Etrich	20.
Nieuport	35.	Tellier	19.
Antoinette	27.	Pischof	17.5
R. E. P. (1909)	27.	Grade	17.
Pfitzner	24.	Hanriot (1 seat)	15.2
R. E. P. (1911)	22.5	Blériot (XI. Cross Chan.).	14.4
Valkyrie	22.5	Sommer	14.
Blériot (XI. 2 bis)	21.	Santos Dumont	12.
“ (XII.)	21.	Blériot XI. (Course)	7.5

TABLE OF POUNDS PER HORSE-POWER FOR BIPLANES

Wright (1909)	41.	Farman (1909)	24.
“ (1911)	37.	Voisin (1909)	23.
Farman (“Michelin”) ..	37.	Curtiss (Passenger)	22.6
Breguet (40 to 50 H.P.)..	36.	Curtiss	22.
Dunne	34.	Farman (Course)	21.
Neale	28.5	M. Farman	21.
Voisin (Bordeaux)	28.	Goupy	21.
Wright (Roadster)	25.4	Paulhan	21.
Breguet (Course 60 H.P.).	25.	Voisin (tractor)	19.
Cody (1909)	25.	Sommer	16.
“ (1911)	25.	Wright (G. B. Racer) ..	14.3
		Dufaux	11.

XII. SPEED AND FLIGHT

The speeds of these aeroplane types are given numerically in the Tables on page. 277. It can be seen at once that the speeds of the machines are all very much alike, the monoplanes not being in general any faster than the biplanes. The Blériot XI. (racer) and the Wright (racer) are now the fastest, and the Farman (Michelin) the slowest. It is noticeable that the speeds of aeroplanes as designed at present seem to have a well-defined limit

beyond which it is difficult to pass. M. Blériot in 1909 made 36 miles an hour on a monoplane driven by a 25 horse-power engine. Upon subsequently increasing the power to 50 horse-power he was barely able to reach a speed of 54 miles a hour, and upon increasing the power to 100 horse-power this year, he was, with the same type, able to make only 58 miles an hour. He then altered the design and finally Leblanc and Morane were able to make over 68 miles an hour.

The speed shows no direct variation with aspect ratio or loading, and higher speed appears to be attained mainly by an excess of power, a decrease of head resistance, and a small size of plane.

It seems doubtful at present whether we can, in an aeroplane, ever get up to a speed of 100 miles an hour. It is quite certain that to accomplish this the general type of aeroplane we now have will need considerable alteration.

In the manner of flight of the different types pronounced distinctions can be drawn.

Probably the widest variation in manner of flight exists between the Antoinette and Farman.

The flight of the Farman machine can best be described as "sluggish." The enormous resistance of this machine seems almost visibly to hold it back, and in making turns the action is slow and "deadened."

In contrast to this is the strikingly birdlike flight of the Antoinette. The resistance of this aeroplane is very small, and consequently the machine darts easily through the air. When changing the direction in any sense or when correcting its stability, the action is precise and well-nigh instantaneous. There is little question that the Antoinette answers its helm better than any other type.

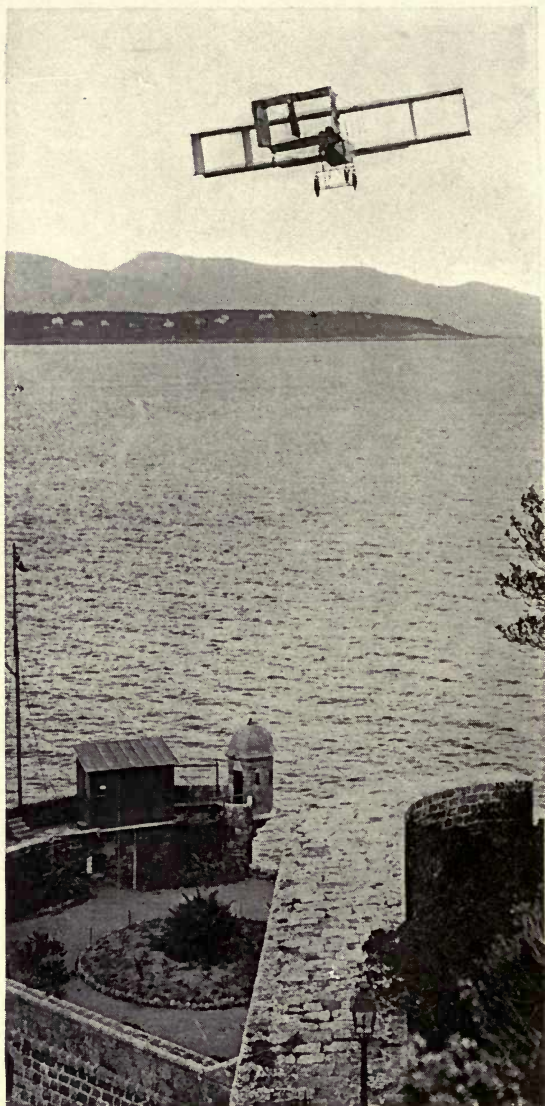
The Blériot approaches the Antoinette in maniability, and the gracefulness of its form makes it also appear very birdlike. The Grade because of its light loading seems especially buoyant on the air, and the other types have characteristics intermediate between the extreme sluggishness of the Farman and large Wright and the preciseness of the Antoinette.

TABLE OF SPEED OF MONOPLANES

Blériot XI. (Course)	69.	Etrich	51.
R. E. P. (1911)	60.	Hanriot	51.
Santos Dumont	55.	Dorner	50.
Sommer	54.	Blériot XI (Cross Chan.) ..	48.
Pischof	53.	“ XII.	48.
Tellier	53.	Valkyrie	46.
Nieuport	52.5	Blériot XI. 2 bis.	42.
Antoinette	52.	Pfützner	42.
Grade	52.	R. E. P. (1909)	39.

TABLE OF SPEED OF BIPLANES

Wright (G. B. Racer)	67.5	Voisin (1909)	35.
Breguet (Course 60 H.P.)	62.	Sommer	46.
Wright (Roadster)	54.5	Goupy	45.
Breguet (40 to 50 H.P.)	53.	Farman (Course)	44.
Voisin (Bordeaux)	51.	Neale	42.
Dufaux	50.	Wright (1911)	42.
Paulhan	50.	Cody (1911)	41.
Voisin (tractor)	50.	Wright (1909)	40.
Curtiss	49.	Dunne	33.
M. Farman	47.	Cody (1909)	37.
Curtiss (Passenger)	46.	Farman (1909)	37.
		Farman (Michelin)	34.



ROUGIER FLYING A VOISIN OVER THE SEA AT MONACO

CHAPTER XIII.

CONTROLLING APPARATUS

The system of control is so important a part of an aeroplane that it is well worth while before treating of accidents to consider the principal controlling systems that are in use more fully than is done in Part II, in order to bring out clearly the distinctions.

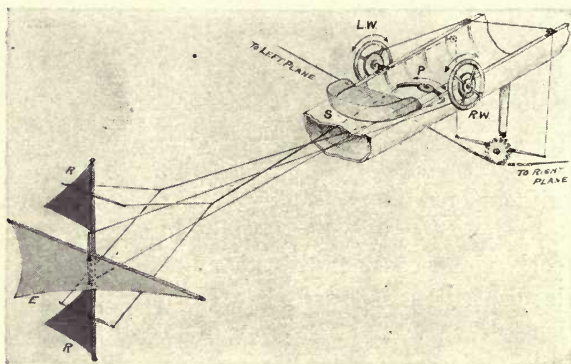
It must be borne in mind, however, that the system of control shown for any one type is not necessarily the one used on every machine of that make. Quite the contrary—there are wide variations from the standard system in every make, dependent primarily on the desire of the purchaser. For example, where foot pedals are used to control the direction rudder, there are two ways of connecting the control wires. The first is to connect them straight, without crossing each other; the control requires in this case that to turn, let us say, to the left, the foot bar be pushed on by the left foot. Many consider this an uninstinctive and therefore undesirable disposition and prefer to have the wires crossed, so that to turn to the left, the right foot is pushed out and the left foot pulled in, the motion being similar to that of an axle placed at the front or the handle-bar on a bicycle. In almost all the foot pedal controls here represented, the latter disposition is given, although in some types, notably the Blériot, the former disposition is more widely used. In many cases the full connections of the control system are not shown, in order to avoid complications; these sketches are merely diagrammatic and distorted for explanatory purposes.

1. THE ANTOINETTE

In the diagram on p. 280 is shown the controlling system of the Antoinette. The aviator seated at S, has a wheel at his right hand RW, controlling the elevation rudder E, and one at his left hand LW, controlling the warping of the main planes. A foot pedal P, operates the direction rudders RR.

If the machine were suddenly to plunge downward, the aviator would quickly turn RW in a counter-clockwise direction and thus turn up E and right the machine. The transmission by crossed wires from the drum of the hand wheel to the arm of the rudder can readily be followed. Due to the variable pull of his propeller and the constant shifting of the center of pressure, Latham is almost continuously jockeying the elevation rudder, slightly, up and down, as one who has seen him in flight could clearly observe.

If the machine tips down suddenly on the left side, then the wire marked "to left plane" must be pulled in, in order that the



THE CONTROLLING SYSTEM OF THE ANTOINETTE MONOPLANE

incidence of the left plane may be increased. To do this the cog mounted on the strut under the frame, and which carries with it the cross arm holding the wires, must be moved in a counter clockwise direction. Therefore the right end of the cross arm must be pulled up, and the left down. By following the wires over their respective pulleys it will be at once observed that to do this, the wheel LW must be turned counter-clockwise. Conversely, to tip up the machine on the right side, LW is moved clockwise, thus pulling in the wire marked "to right plane."

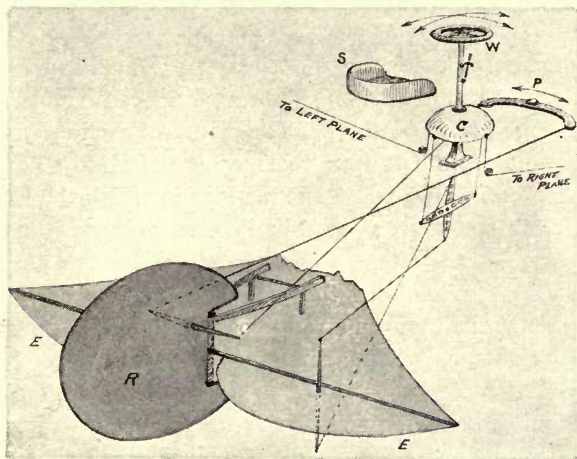
To turn to the left, the aviator pushes on the pedal P with his right foot and thus turns rudders RR exactly as on a boat. If

the wires were not crossed, he would push on P with his left foot for a left turn.

The control system of the Antoinette is ingenious, but hardly instinctive. In fact this is one of the hardest machines to drive, with the possible exception of the Wright.

2. BLÉRIOT

The controlling system of the Blériot "militaire" is shown roughly in the diagram below. The mechanism for the warping wires consisting of a shaft and drum over which the wires lead down to pulleys on the frame strut below the fuselage, and thence out to the planes, is not shown. The wires from the foot pedal are here shown crossed, although the more usual practice appears to be to have them leading direct from the ends of the pedal to the rudder bar.



THE CONTROLLING SYSTEM OF THE BLÉRIOT MONOPLANE

The aviator seated at S operates the rudder R by the bar P as already explained for the Antoinette. In front of him, between his legs, is the *cloche*, consisting of the bell C, a post and the small wheel W. This wheel cannot be turned and is merely

ornamental. The entire *cloche*, however, is universally pivoted and can be moved forward and back or side to side.

By means of the two wires marked "to left plane" and "to right plane," and attached on the side of the *cloche*, the aviator controls the transverse balance. If the left side suddenly tips down, then the *cloche* is quickly moved over to the right, thus pulling in on wire "to left plane," and increasing the incidence of the left side. This action actually, however, takes place through the shaft and drum (not shown).

The flaps of the elevation rudder EE, are controlled by the front to back motion of the *cloche* acting through the wires on the bell and the double lever arm below in such a way that to cause ascent the *cloche* is pulled back towards the seat S, and for descent it is pushed forward.

The Blériot control is instinctive and easy to acquire.

3. BREGUET

On p. 283 is a diagrammatic sketch of the Breguet controlling system, which is probably the most instinctive one in use. All the three controls are united at one place, and all can be operated separately or together as desired. The wire connections are shown very simply here, although on the machine itself the connections are much more complicated. The manner in which the axle of the front wheel is operated in combination with the rudder is likewise not shown.

The wheel W, resembling the wheel on a motor boat, is mounted on an axle at the top of a strong post. This post is mounted on two axes at right angles, thus enabling it to be moved side to side or forward and back.

The side-to-side motion of the post controls the warping through wires "to left plane" and "to right plane" precisely as on the Blériot, the inclination of the post away from any side causing that side to rise up.

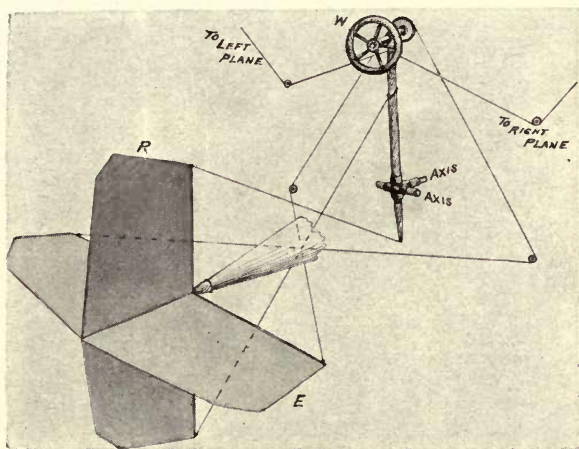
The rudders R and E are rigidly connected, and are together mounted on a single universal joint at the rear of the frame. Therefore whenever R moves from side to side, E swings around from side to side with it and vice versa.

To ascend the aviator pulls the post, wheel W and all towards him. This turns up the tail E and ascent follows.

To turn to any side the wheel W is turned exactly as on an automobile or motor boat. A combined action of warping and rudder for turning is also rendered possible by this system.

It is of importance to point out that in this type of control, the aviator has nothing to hold on to but wheel W. and can therefore, if expert, control the entire machine with one hand.

No simpler controlling apparatus has ever been used, and there



THE BREGUET CONTROLLING SYSTEM

is no doubt that this type has therein an immense advantage over all others.

4. CURTISS

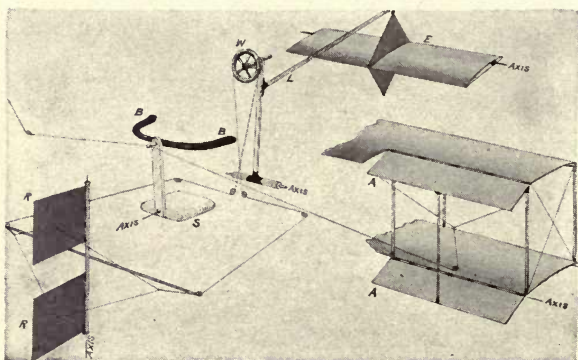
The outstanding feature of the Curtiss system shown in the diagram on page 284 is the operation of the side-control by a brace BB, fitting around the back and arms of the aviator and pivoted on the seat S.

AA are the ailerons of the right side mounted on the trailing edges of the planes with a small steel rod between them, as used on many of the recent Curtiss biplanes. Wires lead from them to

the back of the brace as shown. If the machine suddenly tips down on the right side, it will be necessary to turn down AA, and thus lift up the side. This is done by a very natural movement—i. e., the aviator leans towards the left away from the lowered side.

In front of the seat S is pivoted a post capable of front to back motion, and upon which is mounted a wheel W.

The direction rudders RR are controlled by wheel W exactly as the rudder on a boat. To turn to the right wheel W is turned clockwise.



THE CURTISS CONTROLLING SYSTEM

The control post is connected by a long strut L to the elevation rudder E as shown. On the recent Curtiss machines the elevation rudder is a single plane. By pulling the wheel and post towards him, the aviator will obviously turn up the elevator E and will therefore ascend. To descend the wheel and post are pushed forward thus turning down E.

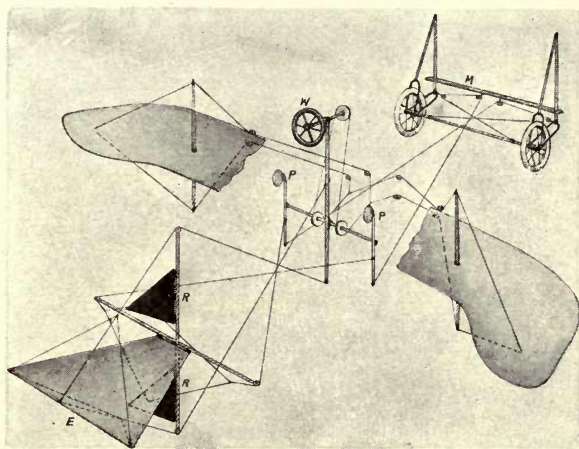
5. ETRICH

The system of control of the Etrich monoplane shown in the diagram on p. 285 appears at first hand to be quite complicated, but it is really very instinctive and works well in practice.

A steering wheel W, governing the warping of the planes, is mounted on a post which can be moved forward and back to con-

trol the elevation rudder E. Two foot pedals PP control in unison the direction rudders RR and the wheels on the mounting chassis M.

If the machine suddenly tips down on the left then the wheel W is turned clockwise, thus increasing the incidence of the left side and turning up the rear of the wing on the right side. The turbine effect that is said to take place on this lowered side has already been explained on p. 123.



THE SYSTEM OF CONTROL OF RUDDERS, ETC., ON THE ETRICH MONOPLANE

The forward and back motion of the post for control of the elevator E is exactly as on the Breguet.

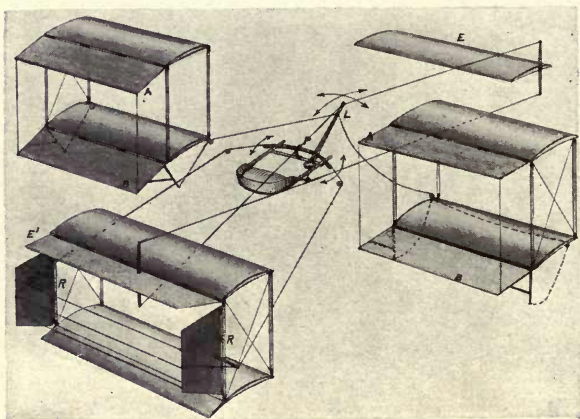
To turn to any side the foot pedal on that side is pressed down. This not only turns the rudders but also the wheels on the chassis as on an automobile. The wire connections must be followed through in order to understand this movement. To turn to the left for example, the left pedal P is pressed down.

6. FARMAN

The Farman single lever and foot pedal control shown in the diagram on p. 286, is probably the most widely used at present. A large lever L mounted on a universal joint is moved forward

and back for control of the elevators EE' , and side to side for control of the ailerons. A foot bar P controls the direction rudders RR in the usual manner.

The two parts of the elevation control consisting of the single plane E at the front and the rear flap E' of the upper deck of the rear cell, are moved jointly by the lever L . Pushing lever L forward will cause E to be turned down and also E' to be turned down, so that the machine will descend. To ascend the lever is pulled in.



THE FARMAN CONTROLLING SYSTEM

If the left side suddenly tipped down then the lever would be moved over to the right as shown. This movement acts by wires on the left ailerons, and pulls them down, thus increasing the lift on that side and causing the machine to rise on that end. At the same time, however, the wires leading to the ailerons on the right side are slacked and they merely flap freely in the wind stream.

This control is very simple and is about as easy to acquire as the Blériot.

For safety the wires leading from the lever to the ailerons and rudders are made double.

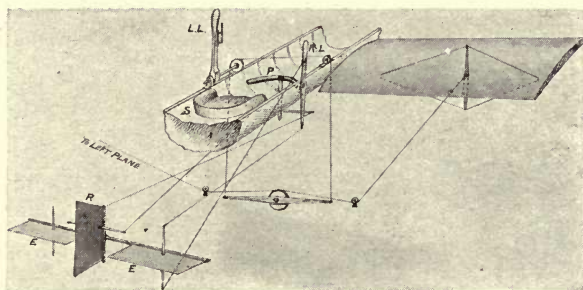
7. HANRIOT

The Hanriot control shown on this page resembles the Antoinette excepting that levers are used instead of wheels. A foot pedal P operating the rudder R is used in the usual fashion.

RL, a lever in the aviator's right hand, can be moved forward and back and controls the elevation rudders EE. When pushed forward, the rudders are turned down and the machine descends; when the lever is pulled back, the machine ascends.

The lever in the aviator's left hand LL is moved from side to side and with it moves the axle and drum to which the cross arm wires are attached, shown on the edge of the left upper side of the skiff-like body.

The wires lead from this drum down to a crossarm which is rigidly fixed to a second drum to which the actual warping wires



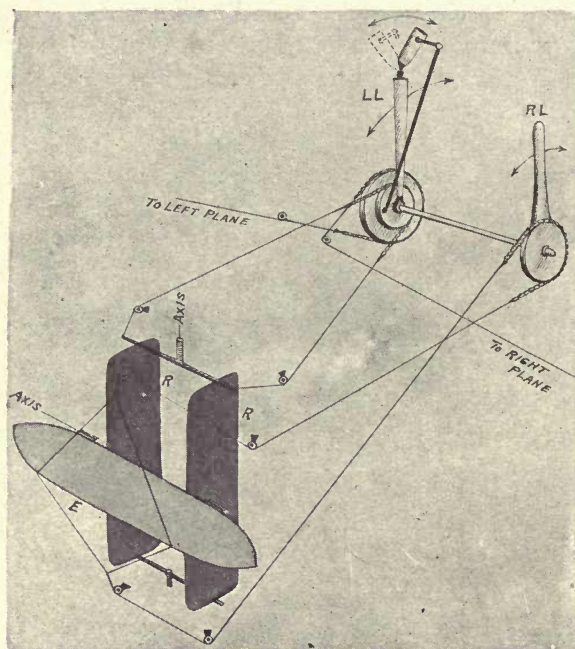
THE HANRIOT CONTROLLING SYSTEM

are attached. If the right side sinks, then to correct the equilibrium the lever LL is moved over to the left. This causes the lower drum and crossarm to move counter clockwise, and by pulling on the wire leading to the right wing, causes its incidence and therefore its lift to be increased.

8. WRIGHT

The new Wright controlling system, see p. 288, is at once the most complicated and the simplest of all the different systems used. The operation is simple enough. The structure, however, is quite intricate.

The system shown below is one of many Wright systems, there being several modifications, depending primarily on whether the operator elevates with his right hand as Wilbur Wright, or with his left hand as Orville Wright, and Brookins. In some instances all the wheels and chains are at one side, and the motion of the outside lever carried through by an inner tube or rod.



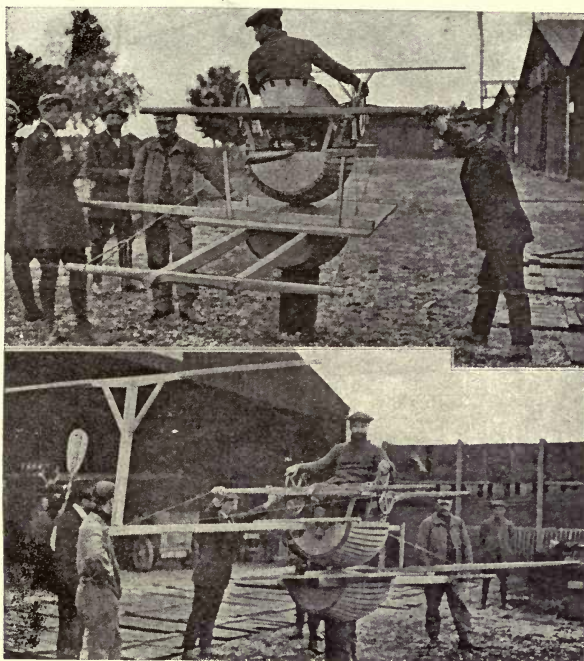
THE WRIGHT CONTROLLING SYSTEM

The operation of the elevation rudder *E* by the lever *RL*, consists merely in pushing the lever forward for descent, and pulling it in for ascent.

The lever marked *LL* operates the rudder and warping combined by a front and back motion. This lever has a movable handle which permits of its being "broken," i. e.: the handle moved

side to side. To "break" a Wright warping and rudder lever is merely to operate this handle.

As already stated, a front to back motion of this lever causes both the warping and the rudders RR to be operated in unison.



THE MACHINE FOR THE INSTRUCTION OF AVIATORS AT THE
ANTOINETTE SCHOOL

The instructor throws the seat in various directions and the pupil, by operating the controls, learns not only to correct any change of position, but is able, after much practice, to catch and prevent any disturbing movement.

But the chains and drums of these two motions although both mounted on the same shaft, are not connected. Therefore the smaller one governing the rudder RR can be moved independently of the other by "breaking" the lever.

If it was desired for example to perform a very sharp turn to

the left the operation would be as follows. The machine is first inclined upward on the right by pushing out on lever LL. This pulls in wire "to right plane" and causes that side to be warped down and therefore to rise. Pushing out on lever LL also causes the rudder RR to be turned to the left (for a left turn). The machine has now acquired the requisite centrifugal action and the lever LL is brought back, but at the same time it is "broken" forcibly over to the left, thus turning the rudder RR alone and causing the machine to "skew" around almost on end. If a spiral "corkscrew" dip were to be executed the same process would be employed, except that in the beginning the elevator would be turned down for a dive to give momentum to the machine, and bring the rudder and warping action into play more strongly.

These are the principal controlling systems, and they differ in degrees of instinctiveness and grouping in which the various motions are united.

The main questions in any controlling system and the ones that can really be settled only by individual preference are:

(1) Whether the control should be direct or indirect, whether the motion of the control should be in the direction in which the machine is to react or opposite to it.

(2) Whether the different controls are to be united at one place, as on the Breguet, or divided separately, as on the Antoinette.

No general advantages of any one system over any other can be laid down because, of course, what appears instinctive to one man, may appear very difficult to another.

CHAPTER XIV.

ACCIDENTS

"La prudence est la vertu des aviateurs."

L. Paulhan.

Railroads, automobiles and in fact all forms of locomotion have their victims. Great mine disasters, industrial catastrophies, fires and explosions claim their toll of human life. But so small does the proportion of fatalities appear to be, that we do not for a moment consider any of these means of locomotion or lines of human endeavor as really dangerous.

Yet the many recent tragedies in aviation are so graphically portrayed and so absorbingly dwelt upon by the press and the public in general that the realization of the negligence on the part of the very aviators who are killed is often obscured. The hasty judgment of the all too credulous world is passed, that it is the aeroplane itself that is fundamentally dangerous.

As a matter of fact, however, if the great care and judgment that is necessary be properly exercised, aviation is as safe if not safer than automobilizing. But in the ability to execute this care and judgment lies the striking difference between Wilbur Wright, Curtiss, Blériot, Farman and the other aviators of the "old school" to whom accidents rarely if ever happen, and the increasing group of reckless and untutored "daredevils," who perform their highly dangerous spirals and volplanes in almost impossible weather, and who in the end usually suffer the tragic death that is awaiting them.

It is as absurd for an aeroplane to be taken out and flown under weather conditions peculiarly hazardous to it alone, as it is for a sailing boat to set out full sail into the teeth of a hurricane.

Almost every summer in the vicinity of New York there occur high and unexpected windstorms, and the next day the newspapers invariably report the loss in human life in drowning from over-

turned sailing craft as anywhere between 10 and 30 victims. It is not every day, by any means, that sailing boats can be navigated in safety and the prudent mariner recognizes this and risks neither himself nor his craft. It is infinitely more important to consider



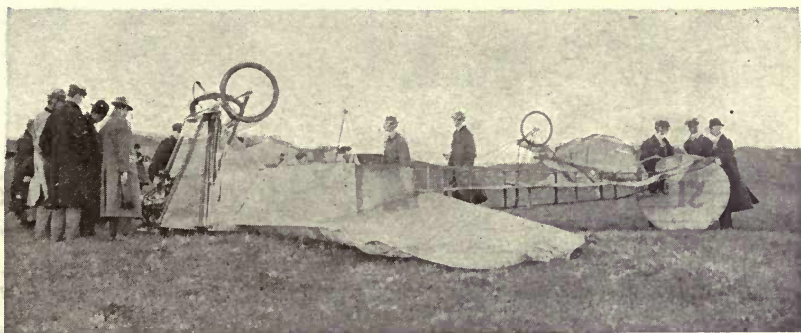
A LIFE PRESERVING GARMENT FOR AVIATORS. WHICH FORMS INTO A PARACHUTE ON FALLING.

the conditions of the atmosphere in aviation. And yet, by the novices they are almost ignored. Flying is indulged in, generally, both here and abroad, in wind conditions that are prohibitive to safety and in almost every case accidents can be traced directly to this source.

Laffont and Pola, Hoxsey and Moisant are but a few of the

victims of their own folly in daring to venture as they did into the swirls and turmoils of the upper air, the existence of which experienced aviators warned them of.

All these catastrophes have a cause, but that which stupefies everyone is that in many cases the cause remains unknown. The fatal plunge is often laid to a broken wire, a splintered spar and finally to a collapsed wing; but a moment of thoughtful investigation shows that all these are not the causes at all. They are merely the effects. Some peculiar combination of forces and pressures has overstrained the part and caused its breakage. In many



A WRECK OF A BLÉRIOT

On Sunday, Oct. 23rd, 1910, at Belmont Park, Moisant attempted to fly his Blériot XI 2 bis in a gale. The machine capsized with the result here depicted.

cases the fall takes place without any breakage at all and can only be due to a loss of equilibrium caused by the disturbing forces.

Whatever the cause, one fact stands out with enormous significance:

Over 80 per cent. of the accidents that have taken place have occurred in conditions of wind that were easily recognized as dangerous.

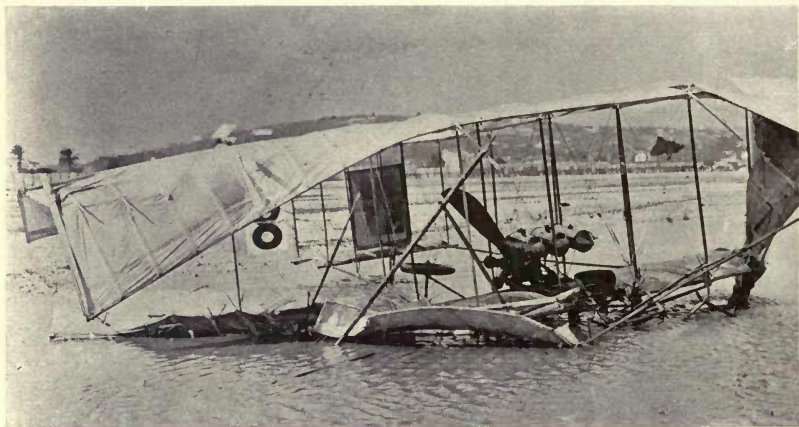
There have been such conflicting reports about many of the accidents that it is almost impossible to describe and explain them.

There are at present, however, nine distinct ways in which accidents are observed to take place.

1. The aviator appears to lose control; the aeroplane begins to sway and dive uncertainly, and finally it lands heavily and is smashed with more or less fatal results to its driver. This has been observed in all kinds of weather, both calm and windy.

2. The aeroplane collides with obstructions either when landing, starting or in mid-air.

3. The aeroplane appears to land too heavily and is in consequence more or less totally wrecked.



THE WRECK OF A FARMAN BIPLANE

At Nice, April 17th, 1910, Chavez on his Farman was suddenly deprived of fuel. The biplane lost headway and landed heavily on the beach, the chassis being completely smashed.

4. In making a turn the equilibrium appears to be lost, and the machine falls in various ways. This is seen to happen most frequently to novices, especially on Blériot-Gnomes.

5. The aeroplane, due to sudden stoppage of the motor, loses headway and falls tail on to the ground.

6. The aeroplane appears to break apart in some way in mid-air while in full horizontal flight, or a broken spar or wire causes loss of balance.

7. While in ordinary motor flight the aeroplane is seen to pitch forward suddenly and dive head on down to the ground, appearing to have lost its support, although no breakage is observed.

8. A similar sudden plunge is frequently seen to occur when the aeroplane is in *volplané*.

9. At the instant when, after a long downward dip, the aeroplane is turned up in order to land tangentially, the wings appear to break loose and fold up overhead with a terrific force.



THE DAMAGE DONE TO AN ANTOINETTE BY A HEAVY "HEAD-ON"
LANDING

The propeller and one wheel are damaged. The planes and frame are intact.

Accidents that occur in the first six ways are easily explainable, and as easily avoidable by the exercise of skill and care. Accidents represented by ways 7, 8 and 9, however, are extremely hard to explain and are causing aviators, constructors, and experts alike a great deal of worry. It is an especial object of this chapter, to present two very plausible explanations of these kinds of accidents, that, if recognized as true, will lead to their practical elimination.

I.

That it is possible for aviators themselves to become physically unable to control their machines, especially after a rapid descent from a high altitude is now believed to be a fact. Labouchère

has described at great length the feeling of extreme nausea that came over him when about to return from a high flight. Morane says that on one occasion after turning off the motor and starting to swoop down from a high altitude, he became so dizzy and felt so ill that he lost completely the control of the machine, and was saved only by fortunate circumstances. Drexel and Latham also testify to this effect of altitude and consider it a form of "mountain



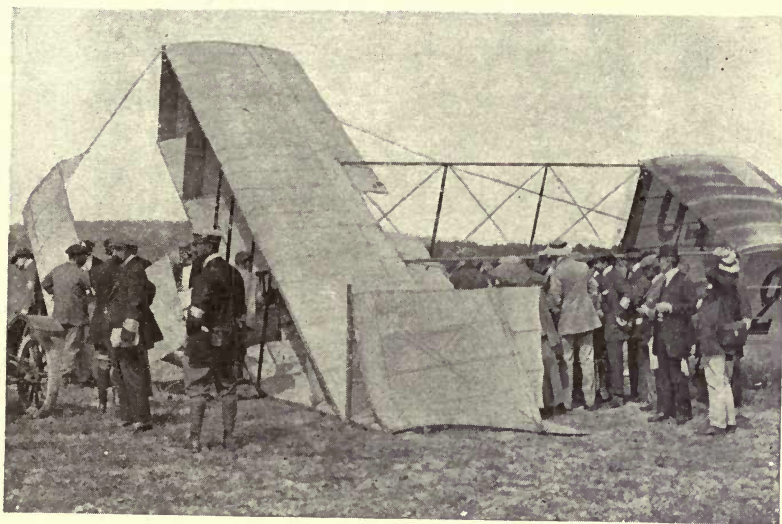
A WRECKED ANTOINETTE AT HELIOPOLIS, EGYPT, IN 1910

sickness." It is said that Chavez, at the end of his great trans-Alpine trip, was affected by this dizziness, and that his fall was due primarily to loss of control, even though the wings were seen to break in mid-air.

Many eminent French physicians, including Prof. Moulinier, have investigated the effect of high altitude on the blood and heart action of aviators, and definitely conclude that in addition to the usual harmful effects of passage from a low to a high altitude, the sudden return from the high altitude to the ground,

which in many cases takes but a few moments, has a very serious effect, that can be withstood for a short time only by men with extremely sound hearts and subtle arteries.

Dizziness, however, does not come from altitude alone. Orville Wright and many French aviators have been troubled by a physical effect of this kind as a result of making numerous short, sharp turns, as Johnstone and Hoxsey were accustomed to do, and many



WRECK OF A VOISIN AT RHEIMS, 1909

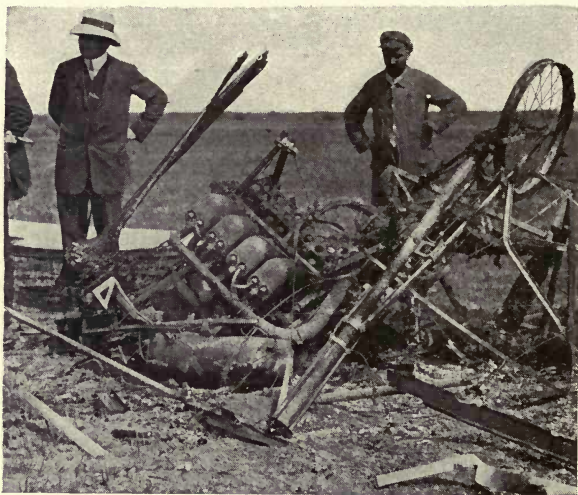
The picture indicates that imperfect lateral stability probably caused the accident.

novices who are likely to get "seasick" find that they become ill on a windy day when the machine pitches a great deal.

The recent fatal accident to Capt. Madiot, who was killed on Oct. 23, 1910, at Douai on a Breguet biplane, and that to Lieut. Willi Mente, who was killed at Magdeburg two days later on a German Wright, appear to have been due to loss of control alone. In both cases the aviators were observed to hesitate and fly uncertainly, and when the machines finally reached the ground, all wire stays, etc., were found intact.

In many cases where an aviator is affected by some form of heart failure, death has occurred before the ground was reached. This is supposed by many to have been the real manner in which Hoxsey died.

There seems now little doubt that in many cases, especially after a long run, an aviator is likely to become tired and nervous and finally so affected by vertigo and possibly fainting, that he loses his presence of mind, mixes up the controls and falls.



WRECK OF THE BLÉRIOT 80 HORSE-POWER MONOPLANE AT
RHEIMS, 1909

This was due to fire, as great a danger to aeroplanes as to other craft. Note the motor and the charred propeller. M. Blériot was bruised and burned.

For all ordinary cases of this kind, the presence of two aviators capable of relieving each other would be a wise precaution.

To avoid the altitude effects, men with weak hearts should never fly above 1000 feet, and the quick downward swoops from high altitudes that have so entertained the public of late should be discouraged.

In accidents due apparently to loss of control, there is, of

course, the possibility of a breakage in the controlling system itself. A wire may snap or a rudder become jammed with very serious consequences. Such care is taken, however, in the construction of most machines, and aviators themselves usually inspect their machines so thoroughly, that accidents due to this source are reasonably avoidable, and when they do occur indicate only negligence.

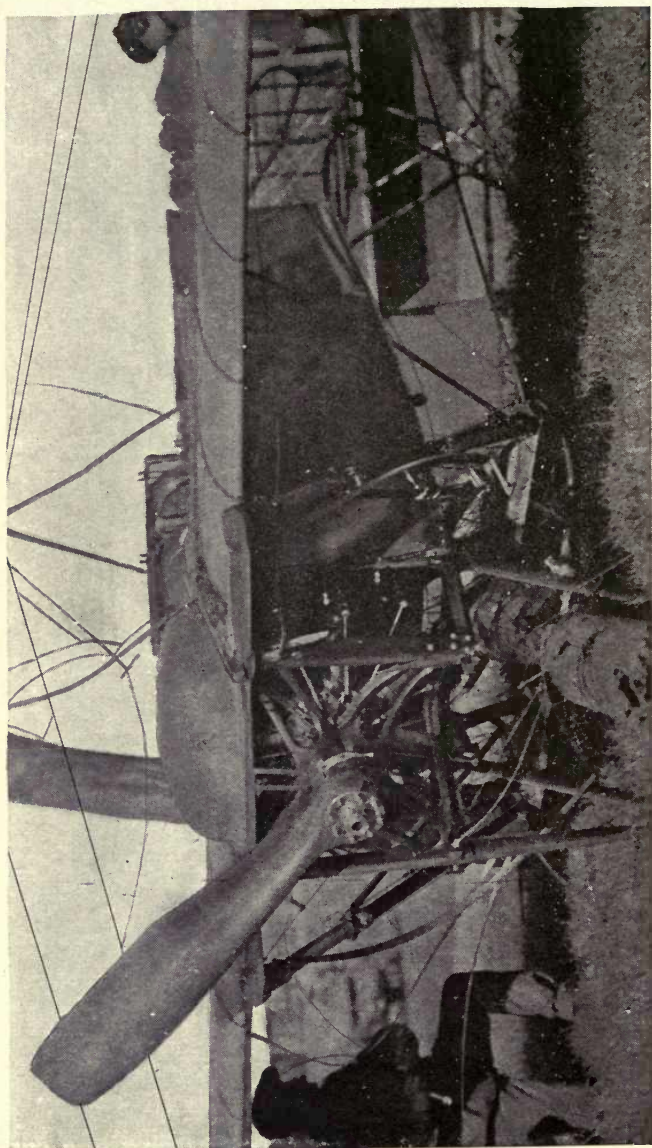


THE 1909 BREGUET BIPLANE JUST AS IT STRUCK THE GROUND
HEAD-ON AT RHEIMS

M. Breguet, who can be seen plunging from his seat, escaped miraculously without any serious injuries. If he had been sitting in front of the motor he probably would have been killed.

2.

Collisions of aeroplanes, with obstacles when landing, starting or in full flight, are of frequent occurrence, and two aeroplanes have been known to collide in mid-air, but the results of such accidents are rarely fatal, although the machines may be totally wrecked. They are as avoidable as collisions in any other form of locomotion, and it is certain that the collision of two aeroplanes headed towards each other in mid-air is much less likely than that



LE BLANC'S 100 HORSE-POWER RACING BLÉRIOT AFTER STRIKING THE TELEPHONE POLE ON LANDING

Le Blanc was on the last lap of the Gordon Bennett race when a sudden leakage of fuel caused him to descend. No sufficiently clear space was available and he crashed into this obstacle with terrific force.

of two automobiles in like circumstances on a road, because of the greater freedom of movement that is available.

The tragic accident to Hauvette-Michelin at Lyon on May 13, 1910, was said to be due to the fact that his Antoinette collided with a pylon, and many other such accidents have happened, though not always with as serious consequences. They point merely to the importance of having a large, clear ground to start from and land on, a provision that is as necessary for aeroplanes as the Ambrose Channel is for the "Mauretania."

3.

That many serious breakages occur from landing too heavily is merely to say that the effect of a fall is collision with the earth. If the aeroplane is too heavily loaded and its speed not high enough to give a "tangential landing" then the shock of impact with the ground may do a great deal of damage from the breakage of a chassis to the complete smashing of the machine; but it has been actually found in practice that if the aviator is strapped in and the aeroplane well designed, he will suffer only a few cuts and bruises.

The wreck that happened to Brookins at Belmont Park when about to start in the Gordon Bennett was due entirely to the fact that the machine had not enough velocity to support the heavy loading and the chassis was too weak to stand the shock of landing. Had the machine had a lighter loading and a stronger chassis, the sudden stoppage of the motor would probably have had no serious effect.

The avoidance of accidents of this kind lies in doing away with the heavy loading, or else in landing at a high enough velocity by keeping the motor running, as is done with many of the high-powered Blériots.

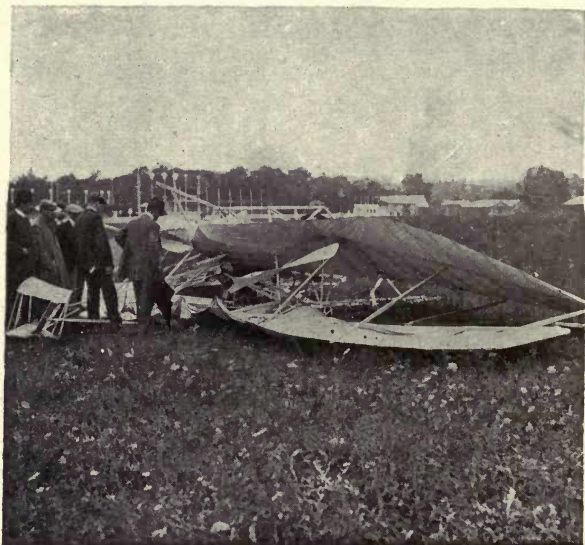
4.

Turning in an aeroplane and especially in one fitted with a Gnome motor, requires a great deal of skill and much practice. It is said abroad that over 75 per cent. of the accidents that happen to novices are due to a sudden fall as a result of a false manœuvre in turning.

Whatever the nature of these accidents, however, they are avoidable only by the acquirement and constant exercise of that ordinary amount of skill that the obtaining of a pilot's license is supposed to require.

5.

Aeroplanes, especially those with large lifting tails like the Farman, are likely to lose headway when the motor suddenly stops.



THE RESULT OF LOSS OF BALANCE DUE TO RISKY FLYING.

The wreck of Lefebvre's Wright machine.

Whether this results in a serious fall or not depends altogether on the skill of the aviator. With a fair amount of presence of mind and a high enough altitude the sudden breaking down of the motor need have no serious consequences. If it is very gusty, however, other effects may take place and complicate the descent.

The habit of many aviators, notably Paulhan and Leblanc, of flying "tail high" is not so much a matter of gaining speed by a reduction of the angle of incidence, as it is a measure of safety that

in case the motor stops suddenly, the machine will at once tend to dive. Fortunately accidents from loss of headway are becoming more and more rare, but they still constitute a large percentage.

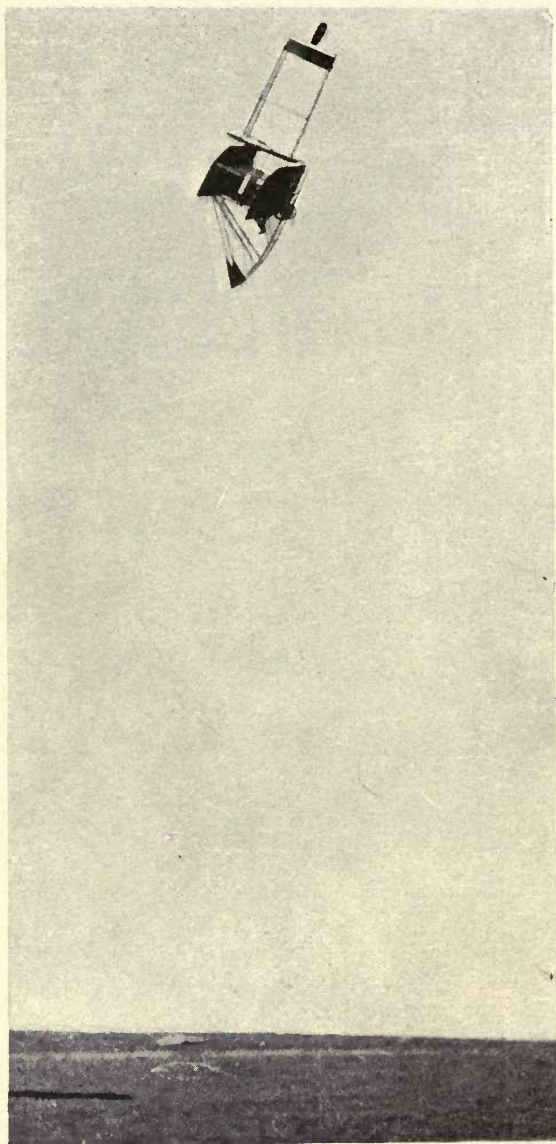
Losses of headway, due to the breakage of any tail piece or the jamming of the elevation rudder in the ascent position are likewise rare, although they are likely to happen and are avoidable only by structural perfection and strength.



A WRECKED FARMAN BIPLANE AT BROOKLANDS

Evidently the surest and safest provision against motor troubles is to equip the aeroplanes with two motors, each alone powerful enough to keep the machine in flight.

One of the most progressive indications of the appreciation of the importance and value of this disposition is the prize of \$15,000 that is generously offered through the *Scientific American* by Edwin Gould, to be awarded for the best performance of an aeroplane equipped with two separate power plants.



HONSEY PLUNGING TO HIS DEATH AT LOS ANGELES

6.

Many accidents, notably those to Delagrangé and LeBlon, were due to so great a weakness in the apparatus that the increased pressure due to an ordinary turn, a passage between gusts or a gyroscopic effect, caused a breakage of the wings. An aeroplane must be designed to stand much higher pressures than those alone necessary for support. The air is very variable, and even on a relatively calm day there are likely to be "holes in the air," and the passage of an aeroplane through these regions causes conditions of pressure that must be resisted by additional strength in the machine. Practically all the breakages that occur in mid-air are due to insufficient strength to resist the variable air pressures that are met, or the peculiar and sudden forces caused by the gyroscopic action of large rotating motors. Only the strongest machines can be flown with safety on a windy day.

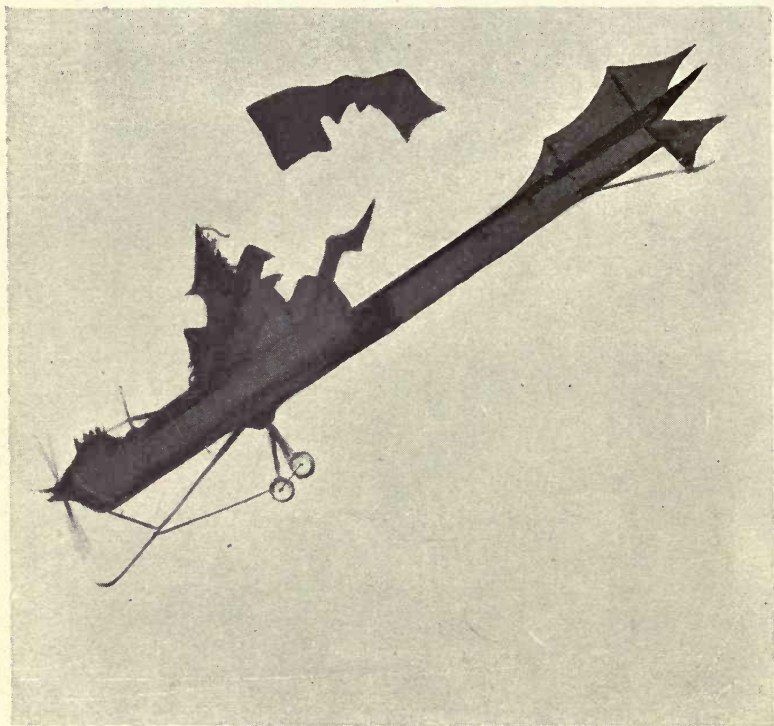
The accident to Rolls appears to have been due entirely to structural weakness. Rolls was flying a French Wright biplane, to which a rear horizontal surface had been added. But the spars designed to hold this surface were much too weak and they snapped when strained by a sudden gust.

Sommer, Farman, Paulhan and Tellier are but a few of the French constructors who fully realizing the great strains an aeroplane is put to, are bending all their efforts to obtain a great strength and solidity of structure. Aeroplanes must be carefully designed and calculated with a large co-efficient of safety.

There are innumerable machines flying to-day where not only no co-efficient of safety exists but where the materials are constantly worked at their elastic limit. The fatigue of materials appears to be ignored, and it seems profitable to do so—until the fatal breakage.

Materials, whether wood or steel, are altered after a time, by oxidation, changes in temperature and repeated vibration. Glued joints are at the mercy of humidity, as is the tightness and strength with which the plane covering fits to the frame. Metal pieces are greatly affected by a combination of magnetic phenomena, changes of temperature, and repeated vibration until after

many million such vibrations the metal undergoes an allotropic transformation, or passes from the fibrous to the dangerous crystalline state. This is recognized in railroading practice, and even though no breakages actually occur, the vibrating parts of locomo-



A SNAPSHOT OF THE TEARING AWAY OF THE WINGS OF THE ANTOINETTE CARRYING LAFFONT AND POLA, AN EXCELLENT EXAMPLE OF THE EFFECT OF CENTRIPETAL FORCE

Note that the rear elevation rudder was turned up, i. e., the machine was about to be brought back to the horizontal. The propeller is in motion.

tives and cars are always replaced after they have run a certain allotted number of miles. It would be wise to adopt this practice in aviation.

The number of aeroplanes that are built and flown in which the

construction is weak and unsafe is fortunately rapidly decreasing. But there still exist aeroplanes of so poor a structure that to attempt to fly in them is, to express it mildly, a very risky matter. At the recent exhibition of aeroplanes in New York City the author had occasion to inspect a biplane that had been constructed by an American firm for a well-known English aviator, and found that one of the wooden spars, leading out to the rear Farman type stabilizing cell, had a large knot-hole about at the center, where the bending moment was greatest, that reduced the effective cross section of the member to almost one-fourth of what it was supposed to be.

Accidents in mid-air to aeroplanes of such a structure are to be expected.

7 and 8.

The sudden dives that are frequently observed and that the aviators who experience them are positive do not result from any false rudder movement are indeed hard to explain. Whether in motor flight or in gliding flight, aeroplanes are again and again seen to pitch forward suddenly and dive towards the ground, as if the supporting power were annulled. Frequently aviators are able to correct this sudden plunge, but unfortunately they are sometimes taken unawares and a fatal drop to the ground results. One fact, however, stands out quite clearly, and that is that *accidents of this kind usually occur in a gusty wind.*

To upset suddenly a mass of the size of an aeroplane requires a considerable force. The gyroscopic force of a rotating Gnome must certainly be appreciable, but it is an open question whether it is considerable enough to jerk the aeroplane down in the manner observed. The effect of this gyroscopic action would more likely be a straining and breakage in the framework itself, and manifest itself as an internal force. To upset the aeroplane, however, some very large external force must act.

On an aeroplane in flight there is no source of external force other than the pressure of the air itself.

In Part I., Chapter V., the characteristics of the movement of the center of pressure on an aeroplane surface are clearly given. It

is definitely known, now, that when an aeroplane is suddenly moved from a low angle of incidence to a still lower one, the center of action of the supporting force moves rapidly to the rear. If this movement is not at once counteracted by the elevation rudder, the aeroplane will be thrown out of equilibrium, because the supporting force will act *in back* of the center of gravity. This will cause a rotating force equal to the weight of the aeroplane acting



CHAVEZ STARTING FROM BRIGUE FOR HIS TRANS-ALPINE FLIGHT

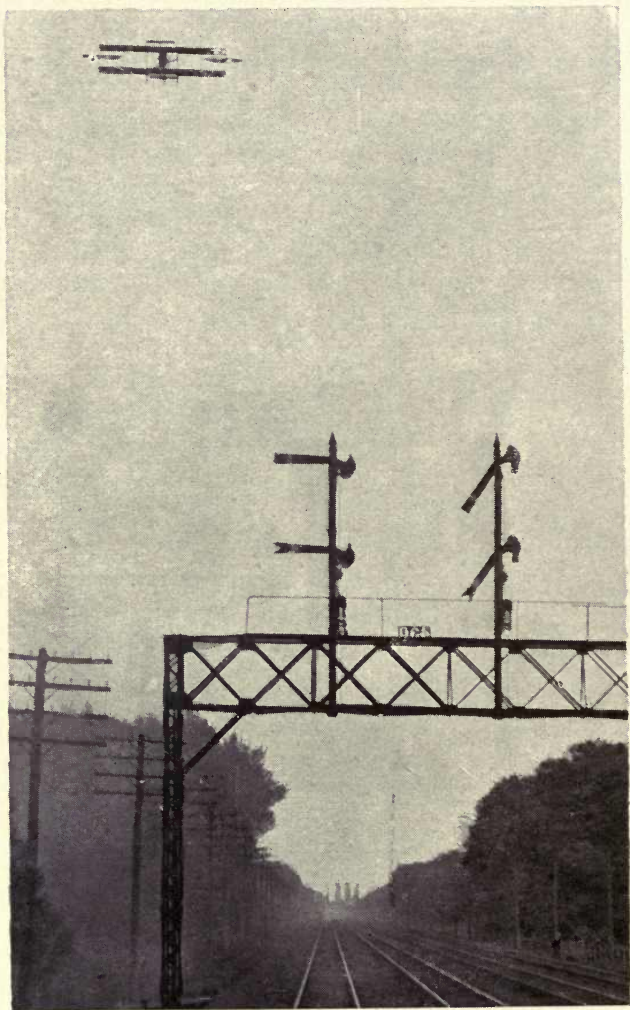
with a lever arm that is the distance between the point of action of the supporting force (c. p.) and the center of gravity (c. g.). This force will turn the rear of the machine up and the front down, and cause the aeroplane to dive, and will do so as suddenly and in as great measure as the angle of incidence is changed. The lower the angle and the greater its sudden additional lowering, the greater will be the movement of the c. p. and consequently the more powerful the disturbing force. The cause of this movement is the pressure of the wind striking the surface of the plane and jerking it down in front.

It is known that in a high and gusty wind *the direction of the wind changes often and very suddenly*. Assuming then that we have an aeroplane moving at an angle of incidence of 5 degrees in a horizontal region of air, if in the nature of a sudden gust, this air region changes to one that is moving downward at an angle of 5 degrees below the horizontal, then the angle of incidence of the aeroplane will as suddenly drop from 5 degrees to 0 degrees.

It must be borne in mind here that the angle of incidence is the angle between the chord of the plane and the relative air current, and that the velocity of the wind itself is immaterial, since it only affects the motion of the aeroplane with respect to the earth, the aeroplane moving through the air at its ordinary velocity.

In this sudden drop from an incidence of 5 degrees to one of 0 degrees, the c. p. would jump back about 2 to 4 feet on a large plane, if the experimental data and facts upon which this is based are at all reliable. We then have a force equal to the weight of the machine, suddenly applied with this large lever arm. The natural consequence, if this force is permitted to act for a fraction of time, is the destruction of the balance and a dive downward. Incidentally it may be pointed out that if the wind were in the rear of the aeroplane, a sudden *upward* gust would have the same effect.

If the aviator is taken unawares, and the change in wind direction very pronounced, the machine will suddenly dive downward and plunge to the ground. On a Wright machine the effect would be to throw the aviator forward on the levers and thus fur-



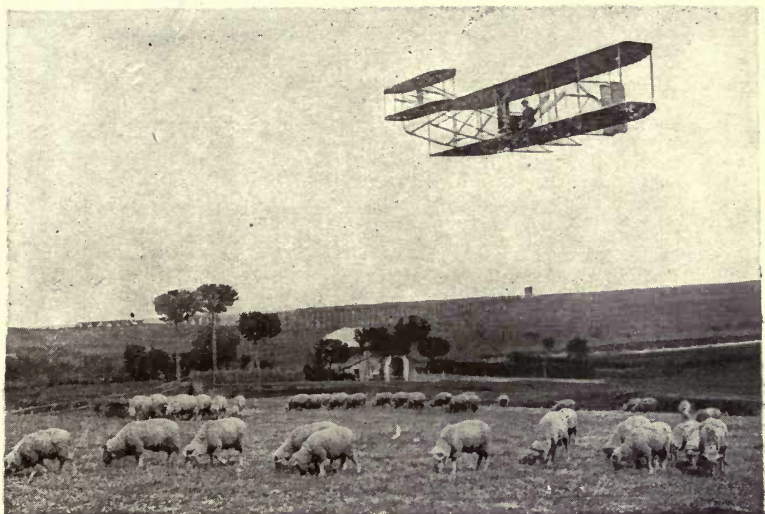
HAMILTON ON HIS CURTISS BIPLANE, TRAVELLING FROM NEW YORK TO PHILADELPHIA, JUNE 13TH, 1910

The semaphores indicate the passage of the train from which this photograph was taken. Great steadiness was displayed the entire trip.

ther accentuate the dive—viz.: Hoxsey. On a Blériot it would throw him on the *cloche*, or if great enough pitch him headlong out of his seat—viz.: Moisant.

9.

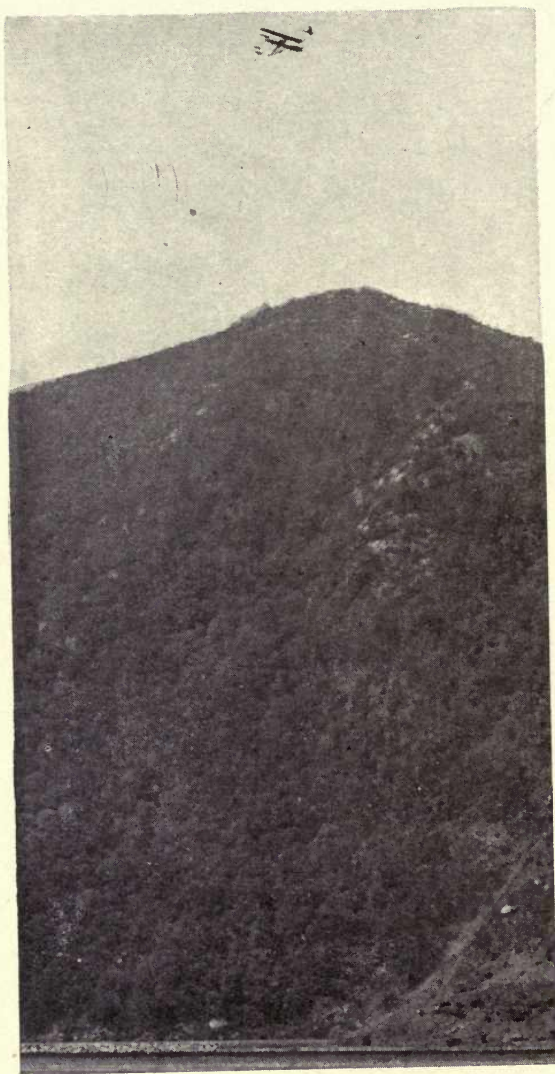
There is one other type of accident that has puzzled aviators as much as the sudden dives—that is the collapsing of the planes of a seemingly strong machine at the moment when it is recovering



WILBUR WRIGHT AT ROME

from a long downward dip, in order to land tangentially. (See No. 1 in the diagram p. 314.)

Probably no other kind of accident is so unexpected and apparently so impossible of explanation. Again and again, Chavez, Blanchard, Laffont and Pola, being only a few of the victims, the aeroplane when just about to turn the arc with center at A (see diagram on p. 314) is seen to quiver for a moment and then the planes are torn away upward from the body and the entire mass crashes to the ground. No other kind of accident is so relentless in its result.



CURTISS PASSING STORM KING ON HIS HISTORICAL ALBANY
TO NEW YORK FLIGHT, MAY 29TH, 1910

Not an accident occurred on this skillfully executed trip.

An explanation is hard to find and though one is given here, decision as to its final value is reserved until more is learned on this highly important subject.

The sudden breakage of the planes is evidently due to an enormously sudden increase of pressure on them.

It is actually known that accidents of this kind occur only after long and steep "dips" or after short "dips" on a very windy day.

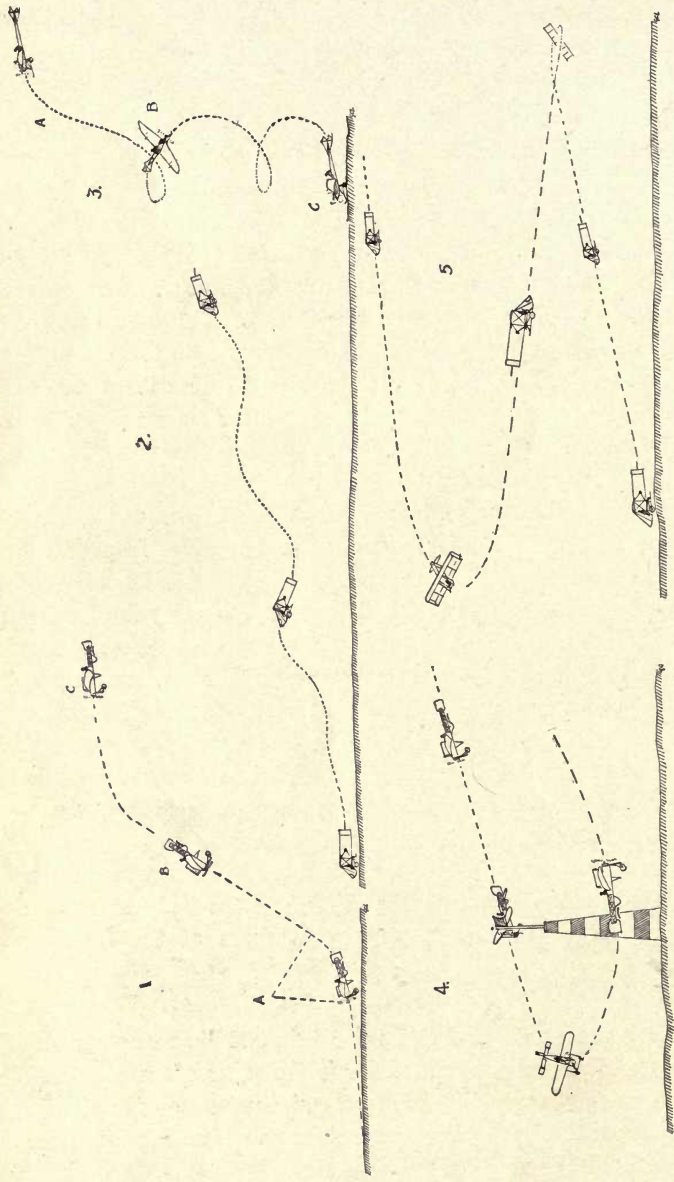
In the diagram on p. 314 is represented an aeroplane making a steep dip. At B the aviator stops the motor and starts to make the dive, and when he gets anywhere within 15 to 150 feet of the ground, depending on his "nerve," he suddenly sets the elevation rudder for ascent, which causes the machine to describe a curved trajectory with center at A, and a radius often as small as 100 feet. The motor is then re-started and the aeroplane travels along a little below the horizontal until finally it lands "tangentially" and the public present applauds the thrilling performance, little realizing its immense danger. As it dives from B the aeroplane gains enormously in velocity, depending altogether, of course, upon how steep the dive is. If at B the velocity is 65 miles an hour and the fall over 800 feet, the velocity at A can easily have risen to 70 miles an hour, if not more, and the momentum of the machine is large. The increased velocity makes the action of the rudders much stronger, due to the increased pressure.

There exists then at the turn a mass of, let us say, 900 pounds, moving at 70 miles an hour, and about to describe the arc of a circle with center at A and a radius possibly 100 feet.

Any mass in order to describe a circle must be constrained to its orbit by a force acting towards the center on the body and from the outer region which is the centripetal force of the familiar

form $\frac{mv^2}{r}$.

Computing the centripetal force for this 900 lb. aeroplane describing this orbit, there is obtained for it *the value of almost 3,000 pounds or more than three times the normal pressure on the planes*. It is little wonder that they tear apart, since this is acting up under the planes to hold the machine towards A.



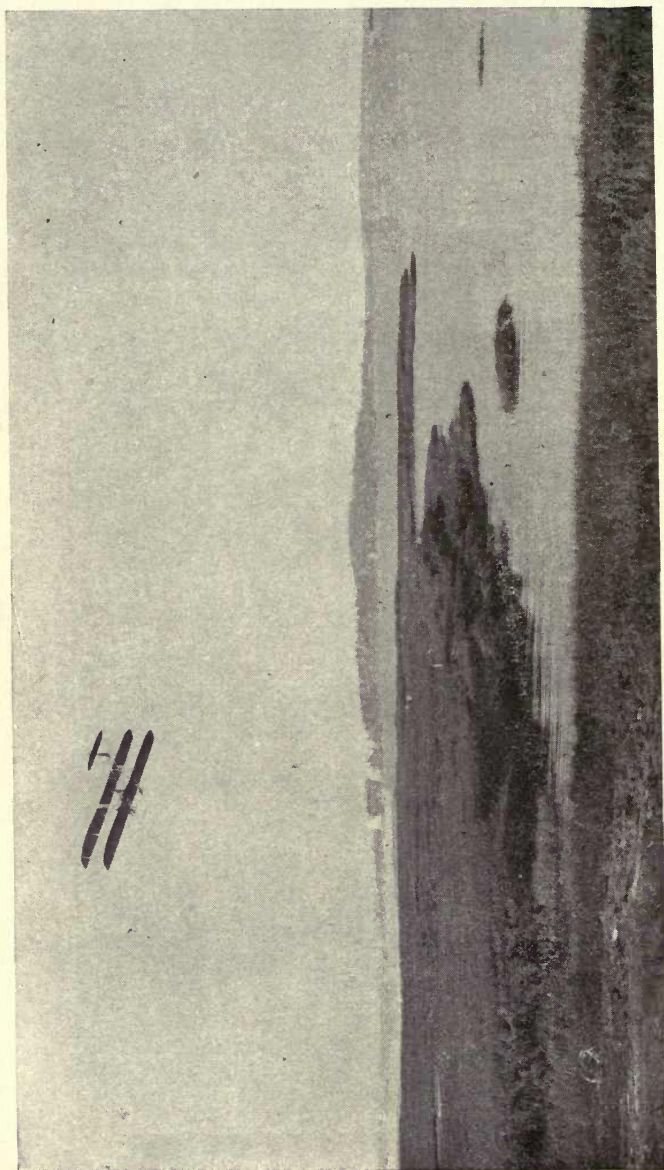
DIAGRAMS OF SOME METHODS OF FLYING

1. A steep "Volplane." At B the aeroplane is falling with motor cut off. At A the turn is made in order to land tangentially. 2. The "ocean-wave." Wilbur Wright coasting down. 3. The "spirally dip," a succession of sharp dives and turns. 4. A skillful turn by Le Blanc, showing how he dives on turning, thus gaining speed. 5. The safest way to "volplane," a long series of descending circles.

This enormous force is as great in its effect as if each side of the plane hit a stationary obstacle at this point. The significance of this centripetal force becomes at once apparent. It is interesting to note in addition that accidents of this kind do actually occur much more frequently to monoplanes than to biplanes. The nature of the bracing explains this.



THE CALM OF THE UPPER AIR IS AT TIMES SERENE
Brookins at Indianapolis, June, 1910.



REAL FLYING WEATHER

Note the calmness of the water and the sailing yachts in the distance. Johnstone in his Wright biplane, hovering over Boston Harbor.

In conclusion it may be said that while accidents of the first six types are fully recognized and therefore more and more avoided, accidents due to the sudden shifting of the center of pressure and to the centripetal force when turning at the bottom of a dip are not yet generally realized and every effort should be bent to their ultimate abolition.

The remedies for these two causes are clearly evident and certainly capable of execution. Two immensely important facts stand out:

1. *Flying in gusty weather conditions is dangerous.*
2. Descending by means of the long, steep "dip" is still more dangerous.

To avoid (1) more care should be exercised by aviators in flying, when conditions are really bad.

To avoid (2) other methods of descent indicated on p. 314 should be used, and the long "dip" should be absolutely prevented or the strength of the machines very greatly increased.

Most of these accidents in aviation, therefore, are avoidable if flying in spirals and steep volplanes for the purpose of thrilling the public is stopped, and if aviators acquire and use better judgment in interpreting the conditions of the weather.

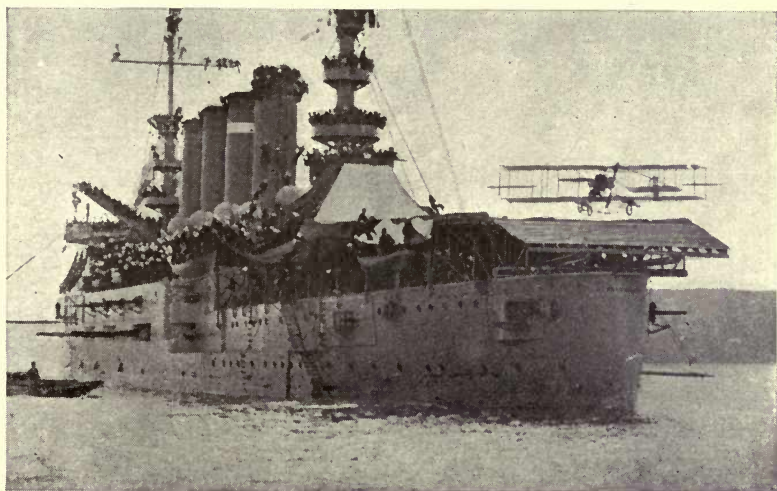


DE LESSEPS CROSSING THE CHANNEL ON HIS BLÉRIOT
XI., MAY 21ST, 1910

CHAPTER XV.

THE VARIABLE SURFACE AEROPLANES

Conditions of starting and landing are the most pronounced limitations to high speed, and it is now becoming recognized that the aeroplane that is able to fly slowly when near the ground and faster and faster in the air, at the will of the pilot, is to mark as

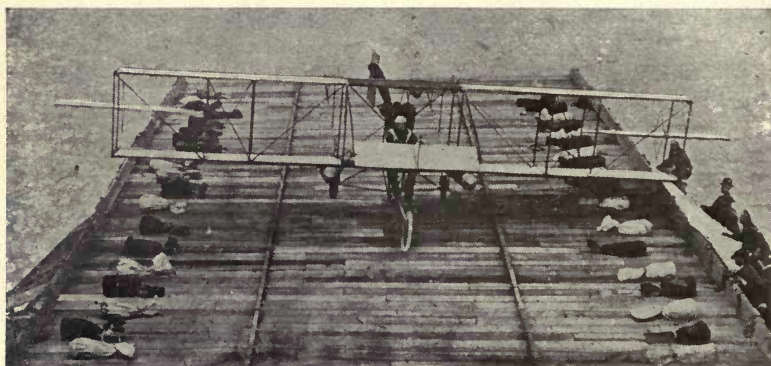


ELY ABOUT TO ALIGHT ON THE CRUISER "PENNSYLVANIA," IN SAN FRANCISCO HARBOR, JAN., 1911

great an advance in aviation as did the introduction of transverse control by the Wrights.

A simple means of effecting this desired range of velocity is to alter the size of the surface itself. It is easily demonstrated from the theory of the aeroplane (see Part I.) that as the velocity is increased, the lifting pressure on the planes also increases and to so great an extent that a much smaller surface is required for sup-

port. Conversely, if the supporting surface itself is decreased, the resistance to motion becomes much less and the velocity at once increases to that required for support with the smaller plane area. So that once the aeroplane is in flight, a great increase of velocity is obtainable by a gradual reduction of the surface area, and in order to decrease the speed to land with safety all that is necessary is to spread out the surface again to its maximum. The limiting factor in this, other than the amount of reduction possible, is the pure head resistance of the framing, which, of course, will not only be the same but will be greatly increased by the higher speed.



ELY'S CURTISS JUST AFTER LANDING ON THE CRUISER

Note the single plane elevator and ailerons at the rear of the main cell. Ely, later, took to flight from the cruiser's deck and returned to his hangar.

Actual computation, on an aeroplane whose maximum surface is 300 square feet and lowest speed of support 50 miles an hour, shows that with the same power upon reducing the surface to 150 square feet the velocity will rise to over 70 miles an hour. The degree with which this could actually be attained in practice can only be determined by actual experiment, but that it is in great measure possible is hardly open to question.

Many means of reducing the surface of an aeroplane have been tried. The commonest suggestion is to cause the tips to turn back horizontally and fold under the central section of the surface, very

much as a bird folds its wings. Another method is to have the outer sections slide in towards the center, thus greatly decreasing the span but leaving the chord constant. Most of these methods

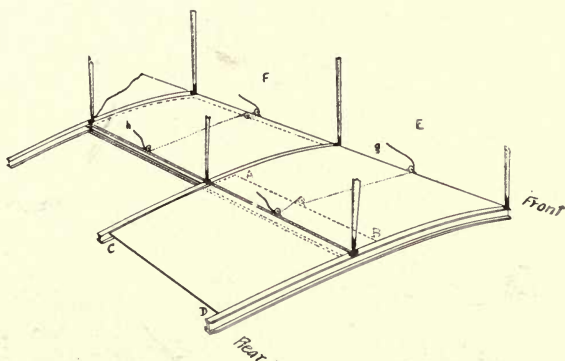
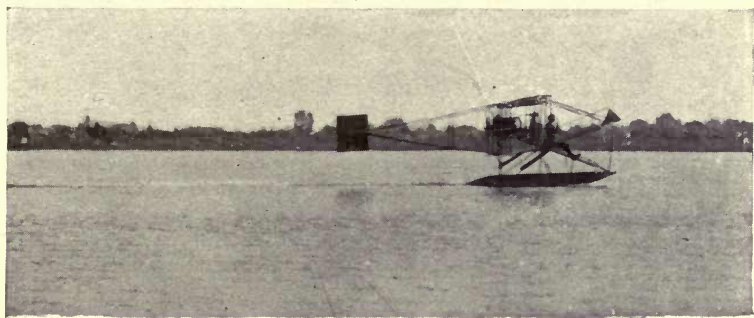


DIAGRAM ILLUSTRATING THE METHOD OF "REEFING" AEROPLANE SURFACES, SUGGESTED HERE

are at present found to be structurally impractical, and in addition to this, reduction of span alone is inadvisable because it reduces the aspect ratio of the plane and therefore causes it to be less efficient.



THE CURTISS HYDRO-AEROPLANE SKIMMING THE SURFACE AT 40 MILES AN HOUR BEFORE RISING

The simple boat-like body under the machine supports it on the water, and as the speed increases it gradually rises entirely clear of the surface. This new development augurs much for the future. It is over water that the aeroplane will find its greatest usefulness.

A method that is structurally feasible and that has many advantageous features, is here suggested.

In the diagram on p. 321 is shown a section of the lower plane of a biplane, illustrating this method of surface reduction. The front section of the plane between the vertical struts is made double surfaced, a considerable clear space being left between the two surfaces, into which the thin surface ABCD can slide. The large I beam ribs are projected out to the rear as shown, and are so constructed that ABCD slides or rolls in a groove on each side.

In panel E, the movable surface is shown extended to the rear.



SIDE VIEW OF THE CURTISS HYDRO-AEROPLANE, SHOWING SINGLE PONTON

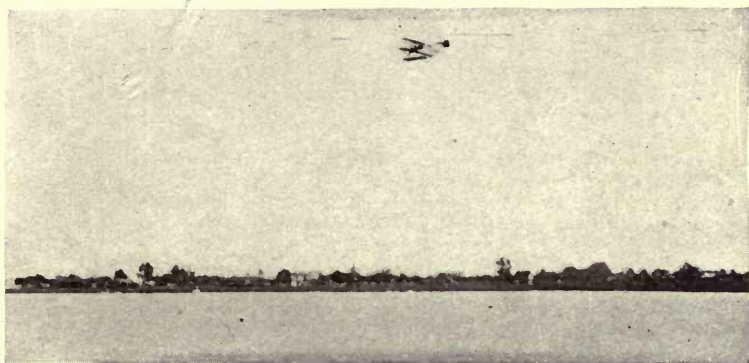
Note the single plane elevation rudder at the front, the flap at the rear of the fan-tail, and the ailerons on the rear posts of the main cell. These are features of the latest Curtiss machines.

If cable *g* is pulled, the surface slides into the space left for it and takes the position shown in panel F. If cable *h* is now pulled the surface will again slide out. There are innumerable ways in which the control of this motion may be effected, but the movements are, combined in such fashion that the surfaces all slide in and out together, in an equal amount, unless an unequal motion on opposite sides is to be used for transverse control, as it easily could be.

The enormous advantage of this method of surface reduction

other than its structural simplicity, is that in reducing the surface, the span is kept constant and the chord only decreased, so that the aspect ratio is greatly increased and the aeroplane rendered much more efficient. The limit of the reduction is a little more than half, as some clearance will always be necessary.

There is one point, however, that will need very careful con-



CURTISS IN FLIGHT AFTER RISING FROM THE WATER

sideration and that is the balancing of the movement of the center of pressure as the reduction takes place.

With the present motors and types of aeroplane structure available, there is little doubt that by use of this method, a racing machine capable of making 85 to 90 miles an hour could be designed with ease.

THE END.



INDEX

	PAGE
ACCIDENTS, consideration of the various kinds and means for their prevention	291-317
Accidents due to physical inability of the aviator, discussion of...	295-299
Accidents, collisions, discussion of.....	299-301
Accidents due to heavy landing, effect of.....	301
Accidents due to lack of skill in turning.....	301-302
Accidents due to sudden loss of motive power, consideration of...	302-303
Accidents due to structural weakness, consideration of.....	305-307
Accidents due to sudden movement of center of pressure, consideration of	307-311
Accidents, effect of sudden centripetal force, discussion.....	311-317
AEROPLANES.	
Aeroplanes, consideration of advantageous disposition of various parts	247-277
Aeroplanes, controlling systems of—description of operation, etc..	279-290
Aeroplanes, definition of use of terms.....	92-93
Aeroplanes, designs of, numerical examples.....	75-89
Aeroplane designs—summary of.....	88
Aeroplanes, efficiency of, discussion.....	270-275
Aeroplanes, characteristics of flight of.....	276
Aeroplanes, methods of flight, diagrams of.....	314
Aeroplanes, loading on, table.....	274
Aeroplane, motive power.....	85
Aeroplanes, pounds carried per horse power, table and consideration of	274-275
Aeroplanes, propellers for.....	86-88
Aeroplane, rudders, design of.....	81-85
Aeroplanes, structure and size, discussion of.....	269-270
Aeroplanes, table of speeds of.....	277
Aeroplane with variable surface, consideration of advantage of....	319-322
AILERONS, discussion of use of.....	260
AIR.	
Effect, density of.....	17
Effect on density of altitude.....	18
Effect on density of state of equilibrium.....	18
AIR PRESSURE ON PLANE.	
Air pressure, calculation of.....	31
Air, pressure of on unit plane, curve.....	31
Air pressure, action on curved inclined plane.....	47
Air pressure on curved surface Lilienthal's table.....	49
Air pressure, calculation of, on flat inclined plane.....	40
Air pressure on flat inclined plane, various formulæ for.....	38
Air, pressure, on inclined surface, consideration of by Newton....	36
Air pressure—on flat inclined plane, references to previous experiments on	43

	PAGE
Air pressure, lift and drift.....	42
Air pressure, position of center of action of.....	61-66
AIR RESISTANCE.	
Air, resistance of.....	17
Air resistance to trains.....	28
Air resistance, Constant K., values as determined by rotating apparatus	29
Air resistance, Constant K. values as determined by straight line motion	30
Air resistance, frictional.....	55-59
Air resistance, frictional, numerical examples.....	56
Air resistance, frictional, Zahm's experiments on.....	56-59
Air resistance, pressure on, effect of.....	17
Air resistance, pressure on normal surface, equation of.....	22
Air resistance, pressure on flat inclined plane, graphical representation of various formulæ.....	39
Air resistance, effect of size of surface on, Kernot.....	27
Air resistance, effect of temperature on, Langley.....	27
Air resistance, variation of with temperature, Wolff.....	27
Air resistance, variation of with velocity, Eiffel.....	26
Air resistance, Smeaton's table.....	23
Air resistance, references to previous works on.....	33
Air resistance, experiments of Aspinall.....	28
Air resistance, experiments of Bender.....	24
Air resistance, Beaufoy.....	22
Air resistance, experiments of Cailletet.....	25
Air resistance, experiments of Canovetti.....	25
Air resistance, experiments of Didion.....	24
Air resistance, experiments of Duchemin.....	24
Air resistance, Eiffel, experiments on air resistance in 1905.....	25
Air resistance, experiments of Hagen.....	24
Air resistance, experiments of Hutton.....	24
Air resistance, experiments of Goupil.....	24
Air resistance, experiments of Langley.....	25
Air resistance, experiments of Pole.....	25
Air resistance, experiments of Poncelet.....	24
Air resistance, experiments of Rayleigh.....	25
Air resistance, experiments of Recknagel.....	24
Air resistance, experiment of Renard.....	25
Air resistance, experiments of Robins.....	21
Air resistance, experiments of Rouse.....	23
Air resistance, Russell, experiments on.....	28
Air resistance, experiments of Stanton.....	26
Air resistance, experiments of Thibault.....	24
Air resistance, experiments of Zahm.....	26
Air resistance, Zossen tests.....	29
AIR STREAM.	
Air stream, Newton's idea of flow of.....	20
Air stream, flow past curved plane at high incidence.....	45
Air stream, flow of, past flat plane at high incidence.....	42
Air stream, flow past a curved plane.....	51
Air stream, flow past a curved surface at low angle of incidence..	48

INDEX

327

	PAGE
Air stream, flow past a normal surface.....	18
Air stream, flow past a circular section.....	24
Air stream, deflection of before normal surface.....	32
Air stream, action of on flat inclined plane.....	35-37
AIR, weight of.....	18
ALTITUDE, effect of on density of air.....	18
ANGLE OF INCIDENCE, air flow on flat inclined plane at high.....	42
Angle of incidence, discussion of best value for.....	264-267
ANTOINETTE MONOPLANE, detailed description of.....	96
Antoinette monoplane, description of controlling system used on..	279-281
Antoinette, machine for the instruction of aviators.....	289
ASPECT RATIO, effect of on lift and drift.....	72-74
Aspect ratio, discussion of effect of.....	263-264
Aspect ratio, table of, monoplanes and biplanes.....	265
ASPINALL, J. A. F., experiments on train resistance.....	28
AUTOMATIC LATERAL STABILITY, discussion of.....	260
AVIATORS, consideration of physical inability of.....	295-299
BEAUFOY ON AIR RESISTANCE.....	22
BIPLANE, numerical example of design of.....	75-89
BIPLANES, detailed descriptions of the prominent types.....	161-245
BLERIOT TYPES.	
Bleriot "aero-bus", monoplane, detailed description of.....	115-117
Bleriot monoplane, description of controlling system used on.....	281
Bleriot, No. VIII.....	13
Bleriot XI. monoplane, detailed description of.....	103
Bleriot XI. 2 bis, detailed description of.....	108
Bleriot XII. monoplane, detailed description of.....	111
BREGUET TYPE.	
Breguet, biplane, detailed description of.....	162
Breguet biplane, description of controlling system used on.....	282
CANOVETTI, experiment on skin friction.....	56
CENTER OF GRAVITY, position of, discussion.....	258-260
CENTER OF PRESSURE, determination of.....	61-66
Center of pressure, position of on flat planes, table.....	62
Center of pressure, references to previous determinations of.....	66
Center of pressure on arched surfaces various determinations of center of pressure on.....	65
Center of pressure, sudden movement of as cause of accidents....	307-311
CENTRIPETAL FORCE, effect of on accidents.....	311-317
CHANUTE, OCTAVE	10
CHANUTE, GLIDERS	11
CODY (1909) BIPLANE, detailed description of.....	167
Cody (1911) biplane, detailed description of.....	171
COLLISIONS OF AEROPLANES, consideration of.....	299-301
CONTROL, TRANSVERSE, comparison of various methods.....	260-262
CONTROLLING APPARATUS, detailed description of systems used.....	279-290
CURTISS TYPES.	
Curtiss biplane, detailed description of.....	174
Curtiss biplane, description of controlling system used on.....	283-284
Curtiss, experiments over water.....	320-323
CURVED SURFACES.	
See also <i>Planes-curved</i> .	

	PAGE
Curved surfaces, experiments of Eiffel on.....	52
Curved surfaces, experiments of Prandtl.....	52
Curved surfaces, experiments of Rateau.....	52
Curved surface, example of calculation of pressure by Lilienthal method	47
Curved surface, Lilienthal's table.....	49
Curved surface, distribution of pressure on.....	66
Curved surface, effect of depth of curvature of on lift and drift...	67
DEFINITION OF TERMS.....	92-93
DENSITY OF AIR, effect of temperature on.....	17
Density of air, effect of altitude on.....	18
DEPTH OF CURVATURE, effect of on lift and drift.....	67-72
DESIGN OF AN AEROPLANE, numerical example of.....	75-89
DIDION, experiments of on falling planes.....	24
DORNER MONOPLANE, detailed description of.....	117
DRIFT AND LIFT, consideration of.....	42
DUCHEMIN, COL., experiments on resistance of fluids.....	24
Duchemin formula for pressure on flat inclined plane.....	38
DUFAUX BIPLANE, detailed description of.....	179
DUNNE BIPLANE, detailed description of.....	182
EFFICIENCY OF AEROPLANES, discussion of.....	270-275
EIFFEL, experiments on air resistance.....	25
Eiffel, experiments on curved surfaces.....	52
Eiffel, lift and drift of curved plane.....	72
Eiffel, determination of position of center of pressure on curved planes	64
Eiffel, investigation of distribution of pressure over curved plane..	66
EQUALIZERS, discussion of use of.....	260
ETRICH MONOPLANE, detailed description of.....	120
FARMAN TYPES.	
Farman, on early Voisin.....	14
Farman (1909) biplane, detailed description of.....	187
Farman biplane, (type Michelin), detailed description of.....	194
Farman biplane, description of controlling system used on.....	285-286
Farman, Maurice, biplane, detailed description of.....	198
FLAT INCLINED PLANE, action of air stream on.....	35-37
Flat inclined plane at high angle of incidence, air flow on.....	42
Flat inclined plane, numerical example of calculation of pressure on	40
Flat inclined plane, various formulæ for pressure on.....	38
Flat inclined plane, graphical representation of various formulæ for pressure on.....	39
Flat inclined planes, position of center of pressure on.....	61
FLIGHT, characteristics of for different types.....	276
Flight, diagrams of various methods of.....	314
FRICTIONAL RESISTANCE OF AIR.....	55-59
Frictional resistance of air, numerical example.....	56
FUSIFORM	20
FUTURE, probable use of variable surface, discussion.....	317-323
GLIDERS, Lilienthal	9
Chanute	11
Wright	11
GOUPY BIPLANE, detailed description of.....	203

	PAGE
GRADE, MONOPLANE, detailed description of.....	124
HAGEN, experiments on air resistance.....	24
HANRIOT MONOPLANE, detailed description of.....	127
Hanriot monoplane, description of controlling system used on.....	287
HASTINGS FORMULA, for pressure on flat inclined planes.....	38
INCLINED PLANE, flat, action of air stream on.....	35-37
INCIDENT ANGLE, discussion of best value for.....	264-267
Incident angle, air flow on flat inclined plane at high.....	42
Inclined plane, various formulæ for pressure on flat.....	38
INSTRUCTION OF AVIATORS, Antoinette machine for.....	289
JOESSEL, experiments on center of pressure on flat planes.....	61
KEELS, discussion of and comparison of dispositions used on prominent types	255-256
KUMMER, experiments of on center of pressure on flat planes.....	62
LANCHESTER, friction of air.....	55
LANGLEY, aerodrome, man-carrying.....	4
Langley, aerodrome, model.....	2
Langley, aerodrome, wreck of.....	5-6
Langley, S. P., experiments in aero-dynamics.....	2
Langley, experiments on air resistance.....	25
Langley, results of experiments on flat inclined plane.....	41
Langley, S. P., determination of position of center of pressure on flat planes	62
Langley, S. P., whirling table.....	2
LIFT AND DRIFT, derivation of.....	42
Lift and drift, effect of aspect ratio on.....	72-74
Lift and drift ratio, Langley.....	50
Lift and drift, ratio of, Lillenthal.....	50
Lift and drift, ratio of for curved plane.....	51-53
Lift and drift, effect of depth of curvature on.....	67-72
Lift and drift of curved plane, Eiffel results on.....	72
Lift to drift, ratio of for curved planes, Prandtl.....	77
Lift and drift, values of for curved plane, by Prandtl.....	67-74
LILIENTHAL, OTTO	7
Lilienthal, consideration of curved surfaces.....	46
Lilienthal's table of curved surfaces.....	49
Lilienthal's method of calculation of pressure, numerical example of	47
Lilienthal, O., gliding experiments.....	8-9
LOADING, effect of on flight.....	272
Loading, table of values for prominent types.....	274
MAXWELL, experiments on air friction.....	55
MONOPLANES.	
Monoplanes, important types of.....	95-159
Monoplanes, detailed diagram of notable types.....	95-159
MOTIVE POWER, determination of.....	85
Motive power, pounds per horse-power, table of values for prominent types	275
MOTOR, position of, discussion.....	257
MOUNTING, discussion of different types and comparison.....	247-250
NEALE BIPLANE, detailed description of.....	207
NEWTON, ISAAC, consideration of flow of air on normal surface.....	20-21
Newton, Isaac, consideration of air pressure on inclined surface...	36
NIEUPORT MONOPLANE, detailed description of.....	130

	PAGE
ODELL, experiments on air friction.....	55
PAULHAN BIPLANE, detailed description of.....	210
PFITZNER MONOPLANE, detailed description of.....	131
PISCHOF MONOPLANE, detailed description of.....	136
PLANES.	
Planes, Aspect Ratio of (see <i>Aspect Ratio</i>).....	
Plane, distribution of pressure on.....	66
Planes, curved	46-53
Plane, curved section chord, etc. to find.....	46
Curved inclined planes, pressures on Lillenthal.....	44
Curved plane, von Dallwitz formula for pressure on.....	51
Curved inclined plane, forces on.....	47
Curved inclined plane, Lillenthal's values.....	46
Curved plane, ratio of lift to drift.....	51-53
Curved plane, position of center of pressure on.....	64-66
Plane, flat inclined, references to previous works on.....	43
Plane, flat inclined, pressure on.....	35-43
Plane, flat inclined, air flow on at high angle of incidence.....	42
Plane, flat inclined, numerical example of calculation of pressure on	40
Plane, normal, effect of air stream on.....	18
PRESSURE, effect of on air resistance.....	17
Pressure of air on normal surface, equation of.....	22
See also under <i>Air</i> .	
POLE, investigation of air friction.....	55
POUNDS, per horse-power for prominent types.....	275
Pounds per square foot of surface, values of for prominent types..	274
PRANDTL, determination of position of center of pressure on curved	
planes	64
PRANDTL, experiments on curved surfaces.....	52
Prandtl, results of experiments on lift and drift of curved planes..	67-74
PRESSURE OF AIR, on normal surface.....	22
Pressure, center of.....	61-66
Pressure, distribution of on curved plane.....	66
PROPELLER, calculation of.....	86-88
Propeller, effect of position on aviator's comfort.....	258
Propellers, discussion of position of.....	267-268
RATEAU, experiments on curved surface.....	52
Rateau, determination of positions of center of pressure on	
curved planes	64
Rateau, determination of position of center of pressure on	
flat planes	62
RATIO OF PRESSURE incline to pressure normal, table.....	41
RAYLEIGH FORMULA for pressure on flat inclined plane.....	38
R. E. P. MONOPLANE (1909), detailed description of.....	140
R. E. P., monoplane (1911, one seat), detailed description of....	145
RESISTANCE OF THE AIR, factors on which it depends.....	17
See also under <i>Air</i> .	
See <i>Air Resistance</i> .	
RUDDERS, forces caused by on aeroplanes.....	82
Rudders, design of.....	81-85
Rudders, discussion of.....	251-254
ROUSE, air resistance.....	23
RUSSELL, experiments on air resistance.....	28

	PAGE
Russell, experiments on train resistance.....	28
SANTOS-DUMONT	14
Santos-Dumont monoplane, detailed description of.....	148
SCREENS, discussion of use of in transverse control.....	260
SEATS, POSITION OF, discussion.....	256
Seats, enclosed, advantages of.....	258
SHAPES—OF LEAST RESISTANCE.....	20
SKIDS, discussion of use of.....	247
Skid and wheel combinations, discussion of use of.....	247
SKIN FRICTION OF AIR.....	55-59
SMEATON, JOHN—Table of air pressure.....	23
SOMMER BIPLANE, detailed description of.....	214
Sommer monoplane, detailed description of.....	151
SPEED, values for prominent types, table.....	277
STABILITY, lateral, discussion.....	260-262
STANTON, experiments on air resistance.....	26
STREAM LINE FORM.....	20
STRUCTURE OF AEROPLANES, weakness as cause of accidents.....	305-307
SURFACE, loading per square foot, table of values for prominent types..	274
Surface, suggested method of varying the size in flight.....	319-321
TELLIER MONOPLANE, detailed description of.....	153
TERMINOLOGY, meaning of.....	92-93
TRANSVERSE CONTROL, comparison of various methods.....	260-262
VOISIN (1909) BIPLANE, detailed description of.....	218
Voisin biplane (tractor screw type) detailed description of.....	222
Voisin biplane (type "Bordeaux"), detailed description of.....	224
Voisin biplane (front control), detailed description of.....	229
WARPING, discussion of use of.....	260
WATER, action of stream passing normal surface.....	19
Water, experiments over by Curtiss.....	320-332
WHIRLING TABLE, Langley, S. P.	2
WRIGHT BROTHERS, early flights of.....	12
Wright types, detailed description of.....	230
Wright biplane (model R), detailed description of.....	237
Wright biplane (1911) model B, detailed description of.....	243
Wright biplane, description of controlling system used on.....	287-290
VALKYRIE MONOPLANE, detailed description of.....	156
VOLPLANE, various methods.....	314
VON DALLWITZ FORMULA, for pressure of curved plane.....	51
ZAHM, experiments on air resistance.....	26
Zahm, determination of frictional resistance of air.....	56-59
Zahm, skin friction table.....	58
ZOSSEN, tests on train resistance of at high speed.....	29

PATENTS

THE WEALTH OF NATIONS

A PATENT gives you an exclusive right to your invention for a term of seventeen years. You can sell, lease, mortgage it, assign portions of it, and grant licenses to manufacture under it. Our Patent system is responsible for much of our industrial progress and our success in competing in the markets of the world. The value of a successful Patent is in no degree commensurate with the almost nominal cost of obtaining it. In order to obtain a Patent it is necessary to employ a Patent Attorney to prepare the specifications and draw the claims. This is a special branch of the legal profession which can only be conducted successfully by experts. For nearly sixty years we have acted as solicitors for thousand of clients in all parts of the world. Our vast experience enabled us to prepare and prosecute Patent cases and Trade Marks at a minimum of expense. Our work is of one quality, and the rates are the same to rich and poor. Our unbiased opinion freely given. We are happy to consult with you in person or by letter as to the probable patentability of your invention.

Hand Book on Patents, Trade Marks, etc., Sent Free on Application

MUNN & COMPANY
SOLICITORS OF PATENTS
Main Office, 361 Broadway, New York
Branch Office, 625 F Street, Washington, D. C.



THIS BOOK IS DUE ON THE LAST DATE
STAMPED BELOW

AN INITIAL FINE OF 25 CENTS
WILL BE ASSESSED FOR FAILURE TO RETURN
THIS BOOK ON THE DATE DUE. THE PENALTY
WILL INCREASE TO 50 CENTS ON THE FOURTH
DAY AND TO \$1.00 ON THE SEVENTH DAY
OVERDUE.

MAR 9 1933

21 Mar '63 RA

21 Mar '63

APR 21 1963

APR 6 1942

AUG 3 - 1966 7 6

3 Feb 52 FF

JUL 27 '66 Z3 RCD

25 Jan 52 L

MAY 12 1972 3 0

8 Nov '53 KW

NOV 9 1953 LD

9 Jan '60 PW

JAN 4 1960

FEB '60 AR LD

FEB 9 1960

REC'D LD APR 29 '72 -9 AM 6 2

LD 21-50m-1, '33

TL 70625

217054

TL 671
13
L6

UNIVERSITY OF CALIFORNIA LIBRARY

